

C 73/7 P 19
95-2

95th Congress }
2d Session }

COMMITTEE PRINT

SELECTED PAPERS ON THE NATIONAL
BUREAU OF STANDARDS

PREPARED AT THE REQUEST OF

HON. HOWARD W. CANNON, *Chairman*
COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE



OCTOBER 1978



Printed for the use of the
Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1978

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(II)

LETTER OF TRANSMITTAL

U.S. SENATE,

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,

October 2, 1978.

DEAR COLLEAGUE: The National Bureau of Standards is the Nation's oldest national laboratory. In the past few years there have been indications that the Bureau's scientific and technical capabilities have declined. This year the Committee on Commerce, Science, and Transportation through its Subcommittee on Science, Technology, and Space conducted the Senate's first oversight hearings on the Bureau in its 77-year history. It is our hope to remedy past neglect and help insure that the Bureau's resources are used effectively.

After oversight hearings and hearings on the Standard Reference Data Act, the committee reported a bill that, for the first time, placed the Bureau on a periodic authorization basis. This provision was considered favorably by the House and funds for the Bureau will now be reauthorized in 2 years instead of on a continuing basis (Public Law 95-322). We hope this arrangement will help Congress and the Nation be more aware of the Bureau's capabilities and needs.

This document contains materials which have been useful to the committee and will aid its future review of the Bureau's operations. Included are a report by the Office of Technology Assessment, an explanation of the recent reorganization of the Bureau, and the 1978 state of the Bureau message by its new director, Dr. Ernest Ambler.

We believe these materials may be of interest to many persons in Government, industry, academia and the general public. To insure their general availability, we have asked that this document be published as a committee print.

We wish to emphasize that this document has neither been approved, disapproved, nor considered by the Committee on Commerce, Science, and Transportation.

Sincerely,

HOWARD W. CANNON,

Chairman, Committee on Commerce, Science, and Transportation.

ADLAI E. STEVENSON,

Chairman, Subcommittee on Science, Technology, and Space.

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(v)

LETTER OF SUBMITTAL

CONGRESS OF THE UNITED STATES,
OFFICE OF TECHNOLOGY ASSESSMENT,
Washington, D.C.

Hon. ADLAI E. STEVENSON,
*Chairman, Subcommittee on Science, Technology, and Space, Committee
on Commerce, Science, and Transportation, U.S. Senate,
Washington, D.C.*

DEAR MR. CHAIRMAN: I am pleased to transmit the enclosed OTA document, "The National Bureau of Standards: A Case Study Within the National Laboratories Assessment."

This case study is an input to OTA's assessment of national laboratories and would have normally appeared as an appendix to the final report of that assessment which is expected to be completed late in the year. However, I am happy to transmit the case study to you at this time to assist in your subcommittee's oversight hearings on the National Bureau of Standards.

The case study was carried out by the OTA staff under the project direction of Ms. Carolee McBee, with substantial assistance from Dr. Albert Teich on the faculty of George Washington University. The study design and report were reviewed by OTA's distinguished Task Force on National Laboratories, as well as by other authorities on the National Bureau of Standards.

Please let us know if you have any questions concerning this study.

Sincerely,

RUSSELL W. PETERSON,
Director.

Enclosure.

NATIONAL BUREAU OF STANDARDS

A CASE STUDY WITHIN THE NATIONAL LABORATORIES ASSESSMENT

FOREWORD

The Federal Government now spends about \$28 billion per year on research and development activities and facilities in the United States. With another \$20 billion per year from the private sector, the total national investment in R. & D. in the United States approaches \$50 billion annually.

Large though this total is, it portrays only the tip of the iceberg of the overall impact of R. & D. on the economy and the quality of life in our society. For R. & D. is the engine that drives the currents of change in our civilization. From R. & D. stem the inventions, techniques, and processes that propel innovations through our economic and social system. Moreover, it has been estimated that, on the average, each person engaged in R. & D. eventually generates 6 to 10 other jobs throughout the economy. As a consequence, the \$50 billion annual national investment in R. & D. has a massive multiplier effect on our entire socioeconomic system.

Therefore, it behooves the Congress to consider this investment carefully and pay close attention to the ways in which it is allocated and used, as well as to the framework of laws, regulations, incentives, and constraints whereby the fruits of scientific research and development are converted into operational results.

Furthermore, R. & D. and the process of innovation help to determine the options and establish many of the parameters whereby specific technologies can be assessed for their potential impacts on society. In order to assess a particular technology, OTA compares its advantages and disadvantages with those of alternative technologies and assesses its impact on economic, social, environmental, and political factors within a perspective of probable future human needs, capabilities, and values.

To carry out its assessments effectively, OTA needs a thorough understanding of the Nation's R. & D. effort and of the process whereby R. & D. results are converted into useful innovations. While helping to strengthen and integrate OTA's overall assessment activities, such understanding also enables OTA to assist the Congress in better shaping the national investment in R. & D. by developing more soundly based R. & D. policies and priorities. Thus through such understanding, OTA can more effectively fulfill its mandate to give Congress early indication of the impacts of technological change.

In response to these needs and the urging of a number of congressional committees and individual members, the OTA Board authorized a program of R. & D. policies and priorities, which became operational in May 1976.

Recognizing that such an assessment cannot be effectively carried out through a single, comprehensive project which attempts to address all facets of the problem, the program was designed to proceed through a series of manageable, interrelated studies which will help to build an understanding of how to maximize the beneficial impacts of our total R. & D. enterprise.

The program has operated with the guidance of three interrelated advisory panels made up of distinguished leaders of science, technology industry, labor, the professions, and the consumer, environmental, and public interest movements.

The Panel on the Health of the Scientific and Technical Enterprise, chaired by Dr. Harvey Brooks, Benjamin Peirce Professor of Technology and Public Policy of Harvard University, has been concerned with ways we can maintain and enhance the health and vitality of the entire scientific and technical enterprise.

The Panel on the Applications of Science and Technology, chaired by Dr. Lewis Branscomb, vice president and chief scientist of the IBM Corp., has been concerned with how we can more effectively apply science and technology to ameliorate the processes of innovation, augment America's international competitive position, solve national and social problems, and enhance the quality of life.

The Panel on Decision Making on R. & D. Policies and Priorities, chaired by Dr. Gilbert White, director of the Institute of Behavioral Science of the University of Colorado, has been concerned with how we improve the decisionmaking processes whereby the Nation establishes policies and priorities for R. & D.

The program will issue a series of reports over the coming months, all of them intended to inform and aid Congress in dealing with the complex issues of R. & D. policies and priorities.

The third of these reports is "The National Bureau of Standards: A Case Study Within the National Laboratories Assessment." Although the final report of that project will not be ready until late in the year, this case study is being made available at this time for the use of the Subcommittee on Science, Technology, and Space of the Senate Committee on Commerce, Science, and Transportation to assist with oversight hearings on the National Bureau of Standards.

RUSSELL W. PETERSON,
Director, Office of Technology Assessment.

PROGRAM ON R. & D. POLICIES AND PRIORITIES STEERING COMMITTEE

Russell W. Peterson, Director, OTA.

Jerome B. Wiesner, Chairman, Technology Assessment Advisory Council.

Lewis M. Branscomb, Chairman, Panel on the Applications of Science and Technology.

Harvey Brooks, Chairman, Panel on Health of the Scientific and Technical Enterprise.

Gilbert F. White, Chairman, Panel on Decision Making on R. & D. Policies and Priorities.

Ellis Mottur, Ex Officio.

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Dr. Donald F. Hornig, Director, Interdisciplinary Programs in Health, Harvard School of Public Health.

Dr. Richard M. Krause, Director, National Institute of Allergy and Infectious Diseases, National Institutes of Health.

Dr. Claire Nader, Independent Consultant.

[NOTE.—The Advisory Task Force provided advice, critique, and assistance throughout this assessment case study, for which the OTA staff is deeply grateful. Although this advisory task force recommended public release of this report, OTA assumes full responsibility for the report and the accuracy of its content.

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[NOTE.—This report is based on the work of Albert H. Teich of Technosciences Associates, Inc.]

ACKNOWLEDGMENTS

The OTA gratefully acknowledges the cooperation and assistance of many individuals who consented to interviews in connection with the data gathering for this report. We especially appreciate the assistance of the following individuals who, in addition to our task force, reviewed the initial report:

Dr. Allen V. Astin, former Director, NBS; Mr. William Carey, member of the Visiting Committee; Ms. Dianne Cormier, OMB; Dr. Robert Dicke, member of the Visiting Committee; Dr. Edwin Gee, chairman of the Statutory Visiting Committee for NBS; Dr. Herbert Hollomon, former Assistant Secretary of Commerce for Science and Technology; Mr. Howard Neviser, Office of the Secretary of Commerce; Dr. Frank Press, Director, Office of Science and Technology Policy; and a number of NBS representatives who willingly gave their time and effort commenting on this report.

The fact that an individual participated in the review of this report does not imply that he or she necessarily agrees with all of its contents.

CONGRESSIONAL SUMMARY

This case study applies the broader issues identified by the National Laboratories Advisory Task Force for OTA's ongoing national laboratories assessment to a particular institution, the National Bureau of

Standards. Although much valuable information was gained for the overall national laboratories assessment as a result of this examination, it was clear that the current needs of oversight committees in the Congress for NBS could be well served by the early transmittal of this report prior to its release as an appendix in the full assessment. Therefore, this report is being made available to present an analysis of the problems and issues relating to one of the important national laboratories, NBS, and to present a variety of options that the congressional oversight committees have for addressing these issues.

This report notes that several of OTA's identified national laboratories issues are of particular importance to the effective functioning of the National Bureau of Standards. These include: Mission and role definition; management difficulties; organizational flexibility; pressures on basic research; and mandated work for other agencies. Other more minor issues specific to NBS are discussed in the main report as well.

Each major issue can be addressed with varying degrees of impact by congressional oversight committees as described below.

FINDINGS AND OPTIONS

ISSUE 1: NBS MISSION IS DIVIDED AND HAS BEEN EXPANDED BEYOND THE ORGANIC ACT

Our analysis reveals that the most crucial factor affecting NBS performance is internal and external confusion regarding its role and mission.

To address this difficulty congressional oversight committees need to understand that NBS mission definition is influenced by the following factors:

(A) The Organic Act spells out two roles: (1) Development and maintenance of measurement sciences and standards, including cooperation with and support of other agencies as needed; (2) technical advisory services to other agencies on scientific and technical problems, not only measurement or standards related.

(B) Subsequent legislation, which specifically directs NBS to perform certain technical activities, such as the Brooks bill, Public Law 89-306, which can catalyze major activities in areas the Bureau had only slightly addressed previously.

(C) Subsequent legislation which directs the Secretary of Commerce to perform certain technical activities, sometimes outside the scope of actual functions allowed in the Organic Act for NBS, but which the Secretary assigns to the Bureau. An example is the amendment to the Flammable Fabrics Act, Public Law 90-189, which authorized the Secretary of Commerce to cooperate with the Secretary of HEW to conduct flammability research "in cooperation with . . . private agencies." This authority was transferred to NBS by the Secretary of Commerce and may be one of the sources of confusion as to whether the Bureau is authorized to work with the private sector in other research areas as well.

(D) Departmental directives which allow certain functions at the Bureau but are not closely related to the functions spelled out in the Organic Act. Certain departmentally approved reorganization plans (such as the one creating an Institute for Applied Technology whose

function it is to "facilitate technological innovation in industry . . ."), would fall in this category.

(E) Budgetary decisions made by either the parent agency, or by the Office of Management and Budget, determine the kinds of activities that are allowed at the NBS. The approval by the OMB of a new initiative in fiscal year 1979 which allows an exploratory program in "cooperative technology" to assist failing industries, and the disapproval of major measurements-oriented programs in air and water pollution illustrate how such decisions direct the way in which the Bureau pursues its activities.

As a result of this variety of definitions of its mission, NBS has had difficulty addressing all the activities it has been asked to perform, and has no clear sense of priority as to which activities, if any, require more concentration. Additionally, NBS is unable to continue to serve as the Nation's lead laboratory for a wide and complex field—measurement sciences and standards—and also respond adequately to the technical service support demands of other agencies, the Congress, and indirectly, the private sector. This stems mainly from the fact that support work performed by NBS on funding from other agencies does not include resources to build competency for future work. The weak link between the missions of NBS and that of the parent agency has led to little support for NBS during the budget process and whenever personnel limitations are distributed throughout the Department. The narrow interpretation by the OMB as to what work should be allowed within NBS has led to an inability on the part of technical experts to prepare for potential measurement and standards needs in many fields, especially environment, health, and energy.

Policy options

Although numerous options are presented in the report for the Congress to utilize in addressing this issue, the OTA has selected the following three as most likely to yield beneficial results.

Option 1—The course of action most likely to have a substantial effect on NBS would be for the Congress to consider a review of the NBS Organic Act and to amend this act to tighten up the definition and limitations on its role. The Congress could stipulate, for example, that all NBS work must be measurements or standards related, thus removing the division in its mission. The Congress could clarify whether or not NBS is authorized to interact with the private sector in areas of research or technical support, other than those relating to measurements and standards. Possible new roles for NBS could be also considered, say in the area of information support for regulatory decisionmaking, as well. The main disadvantage to this action would be the removal of the possibility of using NBS as the last resort for technical work not covered by other agencies as part of their missions. Advantages would be restoration of a single cohesive core function to this laboratory, removal of sources of tension as to support and resources for their work, and a more effective linking of all NBS functions with that of its parent agency.

Central to this review of the Organic Act would be congressional consideration of a yearly budgetary authorization for NBS. This would require NBS to clarify its priorities and defend its program choices to Congress, would provide the opportunity to present a total picture of NBS work to the Congress; and would allow the Congress to express its support for or disagreement with NBS priorities.

Option 2.—The Congress could require the Department of Commerce to articulate how the mission of NBS is integrated with and related to the overall Commerce mission. Specifically, the parent agency could be asked during NBS oversight proceedings to express how NBS technical support activities for other agencies are viewed by the Department, and under what legislative authority the Bureau is assigned roles to work closely with industry on technical matters other than those which are measurements or standards related. The positive impact of this action would be the expression of an integrated role for NBS within the Commerce Department, which could lead to more interest for and support of NBS activities by the parent agency, especially during budgetary proceedings.

Option 3.—The Congress could advance and support efforts to have NBS integrate an expanded economic perspective into its planning and priority setting processes. This would insure that most Bureau program justifications were presented to the Department of Commerce in terms that related to the Commerce mission. It would also insure that Bureau activities were prioritized utilizing more than just the criteria of scientific interest. A modest effort is presented in the fiscal year 1979 budget along these lines. Congress could support this item and emphasize the importance of expanding this function within NBS even further!

ISSUE 2: OMB'S "LEAD AGENCY" CONCEPT PRECIPITATES MANAGEMENT DIFFICULTIES AT NBS

The OMB requires that NBS find funding from lead agencies to do work in areas already covered by the missions of other agencies such as energy, environment, and health, even if such work is merely in anticipation of measurement needs, and has not been directly requested by the other agencies or by the Congress. Even in cases where the activity has been required by mandate, sometimes without funding authorized in the legislation, it has been the responsibility of NBS to approach the lead agency to get the needed funding, or to reprogram existing laboratory activities in order to meet legislative deadlines. The possibility exists in such instances that during the next budget cycle the OMB will take the control of the reprogramed resources from NBS and give it to the lead agency.

Policy options

Option 1.—The Congress could support the fiscal year 1979 budget increase in the amount of funding directly appropriated to the NBS for "competency building" as a percentage of its total operating budget, including other agency funds. The Congress could additionally stipulate that work performed under this funding would be at the discretion of the Director of NBS and could involve anticipatory measurement work in areas covered by other agency missions. Thus, even if OMB continues to utilize its lead agency concept, the Bureau would have some flexibility to pursue work in areas where needs have been identified, but where the lead agency has not specifically requested, or does not desire to fund, the work.

Option 2.—The Congress could encourage the OMB to experiment for at least one or two budget cycles with direct funding to NBS, in total, for other agency work as long as this work has been mandated

(rather than requested) by the other agency or identified by NBS itself as necessary. OMB could establish evaluation criteria which would stipulate that other agency deadlines and needs be met during the performance of another agency's work by the NBS or control of the funding would be remanded to the lead agency.

ISSUE 3: NBS STAFF IS AGING, TURNOVER IS LOW, PERSONNEL CEILINGS INHIBIT ABILITIES

NBS, like many other institutional R. & D. performers, is facing difficulties with organizational flexibility due to its shrinking or steady state staff. The most useful and imaginative research and development is performed when there is a steady infusion of new ideas and approaches, usually provided by expansion of staff with young people, or by a fair degree of rotation of individuals in and out of an organization. NBS is limited in its opportunities to bring in fresh staff members, and has been so limited for the better part of a decade. This has led to lack of up-to-date expertise in some areas, lowered morale, and a reported decline in its ability to perform first-rate research.

Policy options

Option 1.—The Congress could explore possible changes in the civil service system which could create a senior scientific service, preserving tenure rights, but allowing for increased mobility of scientists among national laboratories, including contractor or industry-operated laboratories. Such action would not only benefit NBS and other civil service laboratories, but would also help alleviate similar staffing difficulties in other types of national laboratories as well. This option could be pursued initially by exploring the options available with the Civil Service Commission and various laboratory directors. This effort should take account of and utilize the opportunities presented by the current Presidential review of the civil service system.

Option 2.—The Congress could encourage the Department of Commerce and the OMB to allow NBS to maintain a formalized pool of term personnel appointments, say of 3 to 5 years' duration. The pool would be funded directly each year on a regular basis, would not be subject to any overall personnel ceilings, and would be distributed annually within the Bureau, at the discretion of the Director, to areas of greatest scientific need and interest. This would assure that the laboratory has a group of individuals with a high degree of turnover and/or mobility within the organization, creating at least a minimal flow of new ideas and insights into the ongoing technical work.

Option 3.—The congressional oversight committees could examine the current reorganization of NBS to assess whether this mechanism will contribute substantially to laboratory flexibility. The questions the Congress might concern themselves with include whether the reorganization is merely a change of names with staff essentially performing their old functions; whether new management techniques will be instituted to provide fresh approaches; whether and how the balance of research staff to administrative support staff will be shifted due to the proposed changes; whether inflexibilities in internal staff mobility will be overcome by the reorganization; and whether staff morale has been improved or deteriorated by reorganization.

ISSUE 4: BASIC RESEARCH NECESSARY TO UNDERPIN MUCH OF THE APPLIED MISSION OF NBS HAS SUFFERED CUTBACKS IN RECENT YEARS

The ability of a technical organization to provide accurate measurements and standards at the forefront of a number of areas of science and engineering depends on the understanding and expertise of the professional staff in those areas. Simply, the NBS staff must be highly competent in each area where their expertise is demanded. This competence can be insured by devoting some percentage of NBS research activities to basic research in each area of science and engineering important to its work.

Policy options

Although there are no direct policy options available to the Congress for dealing with this issue, some of the options suggested earlier for clarifying and defining the NBS mission could also lead to beneficial impacts on this basic research problem. For example, if the parent agency explicitly links its own mission with that of NBS, it might be stimulated to serve as a more effective advocate for NBS in the budgetary process for all the laboratory's needs, including resource support for competency building. The report does describe the possible impacts of the declining basic competency at NBS, which may be of importance to congressional oversight committees.

ISSUE 5: CONGRESSIONAL MANDATES TO NBS FOR WORK IN SPECIFIC AREAS HAVE SOMETIMES BEEN HAMPERED BY LACK OF FUNDS AND/ OR PERSONNEL

The report notes that the Bureau generally regards mandated programs as burdens to be borne rather than as opportunities to be explored. Many of these programs have been reassigned to NES by the Commerce Department or require that NBS work under the direction of a lead agency. Some programs have been assigned to NBS despite its lack of capabilities to perform the proposed work. In almost all cases, personnel slots have not been provided to allow staff expansion to take on the new work. In many instances, funds have been difficult to obtain either from the lead agency in control, or from the parent agency. The result has been the necessity on the part of NBS management to reprogram in order to meet legislative deadlines. Such reprogramming has not always been detrimental, and may in fact have led to the clearing away of some outmoded or inappropriate activities. However, there clearly has been some deleterious impact on core mission programs in measurement sciences and standards; traceable mainly to the fact that only a limited staff is available to perform all of the required functions.

Policy options

A few options are available to the Congress on this issue, although the report notes that certain drawbacks are inherent in each.

Option 1.—The Congress could encourage the parent agency to condone temporary personnel expansions at NBS, above the allowed ceilings, if necessary to respond to mandated programs and immediate legislatively imposed deadlines.

Option 2.—The Congress could support a budget initiative for NBS to finance the temporary transfer of skilled industrial and university scientists into the laboratory to work on specific mandated projects under the direction of NBS senior personnel.

Option 3.—The Congress could encourage the laboratory to utilize extramural contracts as a means to approach some of its mandated work. Although the Congress may wish to insure that NBS is integrally involved with a piece of technical work in order to assure its validity and impartiality, this could be specified by requiring NBS to maintain tight monitoring and quality control procedures for contract work.

OTHER ISSUES RELATING SPECIFICALLY TO NBS

A few other issues surfaced in the examination of NBS, which do not fall within the overall topics under examination in the OTA national laboratories assessment. These are presented very briefly in the report for the use of the congressional oversight committees.

These other issues include:

The unwillingness on the part of NBS to utilize extramural contracting for its technical support work to other agencies;

Concern about the operation of the National Academy of Sciences evaluation panels for NBS;

Concerns about the management of the remote laboratory in Boulder, Colo.; and

The apparent lack of strong leadership within NBS which has led to a concentration of decisionmaking power capacity in one of the NBS staff offices, which should function normally only in an advisory capacity to the Director.

CONCLUSION

This OTA report finds that the issues relating to the National Bureau of Standards are important to the future health of some aspects of the Nation's scientific, technical, and economic bases. For that reason, it is felt that positive actions on the part of the congressional oversight committees to address some or all of these issues could prove highly beneficial.

INTRODUCTION

This report is the product of a case study of the National Bureau of Standards conducted under the national laboratories assessment project of the R. & D. policies and priorities program, Office of Technology Assessment. Under the national laboratories assessment, the R. & D. program has been exploring a set of broad policy issues that concern national laboratories in this country. The present study is an analysis of the current NBS situation in terms of these issues.

Recent problems at NBS have received considerable attention in the scientific community and the science affairs press. A headline in C&E News characterized the Bureau as "overworked," while Science described NBS as having suffered "a fall from grace," reported that "malaise pervades its headquarters," and noted that "[o]fficials and laboratory scientists there see a pattern of declining performance and capability that began 10 years ago and picked up speed within the past 5 years."¹

These press accounts are based in part on reports from the NBS statutory visiting committee, and from the National Academy of Sciences evaluation panels, which report on the Bureau annually under contract, as well as on statements of NBS officials and testimony before the House Science and Technology Committee. To the extent they are accurate, they portray an extremely serious situation at the Bureau.

For this assessment, OTA staff and contractors conducted a number of site visits to the Bureau—a total of 2½ days at NBS headquarters in Gaithersburg, Md., and 1 day at the NBS Boulder Laboratories. We interviewed administrative officials and laboratory scientists from all parts and levels of the organization, while also collecting documents and materials. A total of 57 NBS staff members were interviewed, some individually, some in groups. We also met twice with Assistant Secretary of Commerce for Science and Technology Jordan Baruch, and once with the OMB budget examiner responsible for the NBS budget, Dianne Cormier, and we contacted by telephone a number of other relevant individuals. Names of all interviewees appear in appendix A at the end of this report.

This report draws upon our interview notes as well as the publications and documents listed in appendix B. It examines in turn each of the issues identified by the national laboratories task force as relevant to congressional concerns, but only as those issues apply to NBS. These issues, which are discussed in an internal working paper entitled, "National Laboratories Issues, 2d Revision,"² are the product of extensive deliberations among members of the task force. Several issues which do not apply to NBS have been omitted. A number of additional issues of specific concern to NBS are treated in a

¹ "NBS Overworked, Looks to Congress for Relief," C&E News (Nov. 7, 1977), p. 25; Gina Bari Kolata, "National Bureau of Standards: A Fall From Grace," Science (Sept. 2, 1977), pp. 968-970.

² OTA R. & D. Program Document No. H 77-33, May 9, 1977.

separate section at the end of the paper. A subject of considerable current interest at the Bureau, the ongoing reorganization, was treated separately in an internal working report of the OTA.

THE NATIONAL BUREAU OF STANDARDS

In many ways the National Bureau of Standards occupies a unique place among national laboratories in the United States. It is the oldest national laboratory, having been established in 1901. Its mission—which includes providing the Nation with a scientific basis for accurate measurements and a source of information on basic properties of materials, as well as serving the Federal Government as a central capability for technical advice and support—has the broadest national impact. The Bureau has deep ties to the community of basic researchers in physical science, and simultaneously plays an essential role in providing infrastructure for the engineering profession and virtually all phases of American industry. While the Bureau has long been known for its scientific and engineering excellence, its traditional central role in science affairs in the United States has diminished relative to other institutions in the past several decades, perhaps because of the enormous growth that has taken place in the scientific and technological enterprise in this country. The scientific community is now a much larger and more complex entity, and includes many more institutions (such as national laboratories) than it did when the Bureau was younger.

The Bureau is part of the Department of Commerce, reporting, as do the Office of Product Standards, the National Technical Information Service, the Patent Office, the Office of Telecommunications, and the Office of Environmental Affairs, to the Assistant Secretary for Science and Technology. The headquarters and main laboratory facilities of the Bureau are located on a 223-hectare site in Gaithersburg, Md., where over 80 percent of the Bureau's approximately 3,000 employees work. The remainder of the staff is located in Boulder, Colo., at a laboratory established there shortly after World War II, and at the Joint Institute for Laboratory Astrophysics, a basic research institution cosponsored by NBS and the University of Colorado.

Nearly half of the Bureau's staff are physical scientists and engineers, and, of them, approximately 42 percent have earned doctorates. The Bureau has total fiscal year 1978 budget obligations of \$123.6 million, of which \$62.9 million is in the form of directly appropriated funds (so-called "STRS" money),³ \$52.8 million is in funding from other Federal agencies, and \$7.9 million is reimbursable funding received for such things as calibrations, tests, and sales of standard reference materials.

During the time this study was being conducted, the Bureau was planning an internal reorganization, its first such major move since 1964. For the past 13 years, it has been organized into four institutes: the Institute for Basic Standards, IBS, (staff: 867 persons), comprising the Bureau's traditional programs in basic measurement standards; the Institute for Materials Research, IMR, (584 persons), incorporating measurement programs in chemistry and metallurgy; the Institute

³ Science and technology research services.

for Applied Technology, IAT, (672 persons), a unit oriented to problem-solving activities for industry and other Federal agencies; and the Institute for Computer Sciences and Technology, ICST, (177 persons), a unit which provides standards, research, and technical advice aimed at improving the use of computers in the Federal Government. Each institute is comprised of several divisions, and each division is organized into sections, the latter comprising the basic operating units of the Bureau. Under the reorganization, IBS, IMR, and IAT will be incorporated into two units, the National Engineering Laboratory (NEL) and the National Measurements Laboratory (NML), while ICST will remain substantially in its present form.

The Bureau's director, Ernest Ambler, held his post in an acting capacity for 2½ years, and received congressional confirmation early in 1978. He is assisted in his decisionmaking functions by an executive board, including (prior to the reorganization) the heads of the several institutes and a number of other administrative officers, and by a program office, which is concerned with the development, presentation, and administration of the NBS budget. A statutory visiting committee advises the Secretary of Commerce, and the Department, using NBS funds, also contracts with the National Academy of Sciences-National Research Council for annual panel evaluations of each major unit.

ISSUES

MISSION AND ROLE DEFINITION

Probably the key factors governing the organizational health of a national laboratory are the definitions of its mission(s) and role(s). The mission of the laboratory derives from the mission of the support agency and is often perceived differently by the laboratory and the agency. This does not imply that a lab has to serve only a single, narrowly-defined mission, or that its mission cannot change over time. . . . [However] it is important that at a given point the laboratory staff have a firm idea of what the laboratory is supposed to be doing and how its activities fit into their sponsoring agency's mission and its larger societal context. . . . Uncertainty about mission in a laboratory is often at the root of a variety of organizational ills including low morale and declining productivity.⁴

In contrast to many national laboratories, the National Bureau of Standards has a mission which is clearly spelled out by statute. The NBS Organic Act of 1901 (Public Law 56-177), as amended in 1950 (by Public Law 81-619) authorizes the Secretary of Commerce to undertake the following functions:

The custody, maintenance, and development of the national standards of measurement, and the provision of means and methods for making measurements consistent with those standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government.

The determination of physical constants and properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

Cooperation with other governmental agencies and with private organizations in the establishment of standard practices, incorporated in codes and specifications.

Advisory service to Government agencies on scientific and technical problems. Invention and development of devices to serve special needs of the Government.

⁴ "National Laboratories Issues," op. cit., pp. 3-4.

The apparent clarity of this mission statement is misleading, however. First of all a laboratory's actual mission can evolve into a form which differs substantially from its formal mission statement. This can result from legislation, as well as from the cumulative effects of management decisions in the laboratory and the parent agency. In the case of the Bureau, the formal mission contains a fundamental quality which is reflected in the character of the laboratory's actual work. The five functions specified in the Organic Act can be grouped into two major elements; (a) national responsibility for standards and measurements; and (b) technical support to other Government agencies. The standards and measurement role includes much applied work. In fulfilling it, however, the Bureau must pursue basic research in measurement sciences on a broad front. Standards and measurements are generally regarded as the core of the Bureau's mission, and are what the Bureau is most widely known for in the scientific community. There is little dispute about this part of the NBS mission. On the other hand, the second element, the Bureau's technical support functions to other Government agencies are as much a part of its essence as its standards and measurements work. Although it is widely believed that these technical support functions to other agencies should derive only from the Bureau's standards and measurements role, in fact, the Organic Act allows for much broader interpretation. Subsequent legislation, in addition to utilizing this expansion of purpose beyond standards and measurements, has also authorized NBS assistance to the private sector in such areas as flammability research, thus, further expanding its role. The technical support functions date back to the Bureau's origin, and most political decision-makers concerned with the Bureau regard them as at least equal in importance to the Bureau's other work. Thus, as John Lyons, director of the newly formed National Engineering Laboratory at NBS put it, "The bureau has no single mission; in fact, it has always been a bit schizophrenic in this respect."

The duality in the Bureau's mission and the need to keep the two elements in balance is a source of tension inside and outside of the Bureau. Much has been written about the essential nature of NBS's standards and measurements mission and its importance for the maintenance of commerce and science in this country. There is no doubt that the conduct of both American commerce and American scientific research would suffer enormously in the absence of the functions NBS performs. Nevertheless, the critical nature of much of the work the Bureau does in this area, both basic and applied, is often difficult to communicate to nonscientists. The general public, as well as many political decisionmakers, who derive only indirect benefits from this work, probably take much of it for granted. The value of the NBS technical support functions, on the other hand, is easily seen by nonscientists, since these functions are carried out in service to specific clients or Government purposes. The Bureau's leadership and most influential external constituents have traditionally reflected values more congenial to its standards and measurements mission, while its technical support mission has generally received greater and more consistent political backing. The tension between the two sides of the Bureau's identity has been a theme throughout the Bureau's history and awareness of it is a key to understanding its current situation.

One other key to clarifying the Bureau's mission is its relationship to the overall mission of the Commerce Department. Despite the long-term importance of its contribution to the Nation's scientific and technological infrastructure, and hence to the maintenance of commerce, the work of NBS appears to have relatively little direct relation to the day-to-day activities and concerns of its parent agency. Historically, officials at the Department level have not demonstrated a great deal of understanding of the potential contributions of the Bureau's measurements and standards work to departmental objectives. As a result, the Department has not been a particularly strong advocate for the Bureau's interests. Related to this is the fact that the external constituency for the standards and measurements mission, although broad based, is diffuse and not particularly strong or well organized, and does not overlap to any great extent with the constituencies for other Commerce Department missions. And for their part, NBS officials have not been particularly effective in articulating to their Commerce Department superiors how economic objectives can be furthered through the scientific and technical activities of the laboratory.

All of this is part of a larger and more fundamental problem relating relating to the Federal Government's role in the support of R. & D. in the civilian economy. While there is apparently national consensus behind the notion that the Government should play some role in providing the scientific and technological infrastructure for the civilian economy, the nature and extent of that role have never really been clearly defined. A variety of programs has been proposed, and some implemented (for example, the experimental R. & D. incentives program of the National Science Foundation, and DOC's State technical services program) with only scattered results to show for the efforts invested. Until both Congress and the executive branch seriously address the question of what is needed in the way of scientific and technological infrastructure, what part the Federal Government should play in providing it, and how various parts of the executive branch, particularly the Commerce Department, can be motivated to contribute to it, the overall problem will remain and NBS, which provides some of the infrastructure, will have difficulties in its relations with DOC.

Short of a comprehensive resolution of this problem, there are a number of possible approaches to articulating and clarifying the interpretation of the NBS mission for measurements and standards. Three options are: (1) The Department could examine its own mission and make an explicit attempt to strengthen the ties between the Bureau's measurement and standards work and the other activities of the Department; (2) NBS could integrate an expanded economic perspective into its planning and priority-setting processes; and (3) the possibility of removing the Bureau from the Commerce Department could be considered.

The first option could stimulate the Department to serve as a more effective advocate for the Bureau's measurement and standards work, both with the Executive Office and with Congress.

The second option could assist the Bureau in assessing the importance of its activities as they relate to overall Commerce Department objectives. In fact, for fiscal year 1979, the Office of Management and Budget inserted a modest planning initiative in the NBS budget,

including a charge to examine NBS priorities in economic terms. This is at least a step in the right direction.

The third option, that is, the transfer of NBS out of DOC, has been suggested several times. Some proposals have called for integration of NBS into a central scientific and technical agency or department, while others have suggested that the Bureau become an independent agency. The potential effects on both the Bureau and the Department are uncertain. Much analysis of this move, and its effects on the measurement and standards system in this Nation, would have to be performed prior to serious consideration of removal of NBS from the DOC jurisdiction. Therefore, this option probably does not merit careful consideration until serious efforts have been made to address the other approaches.

The relationship to the Commerce Department of the Bureau's technical support services for other agencies is even more problematical than its measurement and standards work. Since these services support other functional areas, outside of Commerce, there is even less enthusiasm for these activities at the Department level. Although other agencies do provide funds for the service work, they traditionally do not provide the funds to build the in-house competency to sustain such service work.

At the same time, however, the Bureau's reputation for technical excellence, the wide range of its talent, and its sheer availability in an era of increasing Government involvement in technical matters have led to a marked growth in demand for its technical support services. Other agencies increasingly seek its aid, and Congress has, on numerous occasions in recent years, stipulated or precipitated NBS involvement in new programs without always providing funds for the purpose. The result has been the addition of many new responsibilities to the Bureau without net growth, sometimes forcing management to opt for displacement of portions of the Bureau's core measurement and standards function.

Another difficulty is that the Bureau has been directed by certain legislation to act in a role to support industry on specific technical matters. It has never been clarified whether the intent of Congress was to expand the NBS support function to industry in total, or only for those particular activities stipulated in the legislation.

Two options seem possible for clarifying the role of the NBS support mission and for dealing with the competency needed in order to provide such technical services. The first would be for the Department to recognize that technical support services are a part of the overall commerce mission, but simply have been assigned by statute to one of their units, NBS. Then Commerce would be more encouraged to advocate the need for the Bureau to obtain direct funding for competency building in those areas during the budgetary process. This would require a complete inventory of the technical service support work now ongoing at NBS, and an assessment of the complementary direct funding required for competency building in order to fulfill service obligations. There should also be a long-range planning effort to identify areas of future service support needs, in order to prepare the Bureau to respond in a timely fashion. For example, if it seems likely that other agencies will be requesting future technical support in an area such as environmental sciences, the Bureau could be allowed to build up a modest degree of competency in anticipation.

The budget approved by OMB for fiscal year 1979 does allow a modest competency building fund, although it is not yet clear how much freedom NBS will have in determining the areas to which that funding may apply.

The second option would be for other agency fund transfers to include a certain percentage of on-the-top funding to build up competency or replenish depleted stores of expertise. This is a common practice utilized by the Department of Energy in financing applied weapons development work at several national laboratories. It is also done by the Department of Defense in its contracting with the aerospace industry for development work. Strong congressional and departmental support for clauses to support this type of funding in the agreements governing transfers from other agencies would most likely be required, however.

A third option would not provide a means of obtaining competency support for technical services, but would remove the need for such support. This would be an amendment of the Organic Act to narrow the provision of technical services only to those relating directly to measurements and standards. Since the Department and the Office of Management and Budget should support direct funding for competency building in any areas of measurements and standards deemed to be of high priority for NBS at a given time, this would insure backing for competency building in both elements of the mission. Although this action would clarify the role of NBS, and would provide a central theme for all its work, whether developmental, applied, or service oriented, it would also remove the possibility of using the NBS as the home of "last resort" for technical work that is not addressed by the other functional agencies. Congress has often been concerned that a piece of technical work should be done, and has assigned it to NBS (or the Secretary of Commerce) for lack of any other more likely performer. This was certainly the case with the large and well-regarded fire research program at NBS. A corollary to this option would be for Congress to also clarify whether NBS technical support to industry is to be limited to provision of infrastructure in the form of measurements and standards only, unless specifically directed by mandate to do otherwise.

Although the duality in mission and its unusual breadth have caused difficulties for the Bureau, they do not necessarily have to be regarded as handicaps. On the contrary, properly viewed by all concerned they can be sources of great strength for the Bureau. The development of measurement science and the provision of applied research in support of the objectives of a variety of agencies can be synergistic—each contributing to excellence in the other. Both elements of the mission require the conduct of basic research, however, if excellence is to be maintained. Evidence would seem to indicate that the Bureau's and the Department's leadership have not been sufficiently forceful in asserting the importance of both aspects of the NBS mission and in emphasizing the inherent synergisms. External observers comment that in certain years, the Bureau seems to represent itself as an applied research organization, in other years as a basic research institution, depending on how the leadership seems to feel the wind is blowing. Although some of the blame for this might well rest with attempts to please an indifferent parent agency, the result is some confusion among significant outsiders as to how the

Bureau views its own mission. The intent is not to make the mission itself more rigid. Rather it is to make the sense of mission sufficiently strong throughout the Bureau that staff members understand how their activities fit into and support that mission, and that persons on the outside and within the Department perceive the mission's importance and the Bureau's commitment to it.

As a final note, it might be suggested that one way in which a stronger sense of mission might be reflected operationally would be for the parent agency to work more closely with Congress during the development of anticipated legislative initiatives. This would help to assure that any new mandates are consistent with the Bureau's mission, and are accompanied by sufficient additional funds and personnel slots; or are added with a clear understanding of their impacts on existing Bureau programs. This requires that the Bureau maintain an awareness of potential mandates, assess their impact on existing programs, and inform the Department. Both the Department and the Bureau must be willing to work for modification of mandates it feels will be detrimental to the performance of a balanced mission, and must view those mandates received as opportunities rather than as burdens. The subject is discussed more extensively below in the section on redeployment and intergovernmental access.

LEVEL OF MANAGEMENT

The balance in control of an R. & D. program between the administrative organization at agency headquarters and the scientific staff in the field laboratory is an extremely delicate one and a perpetual source of tension in technology-intensive agencies. [Agency] administration should be strong enough to insure that the laboratory's work will be applicable to its own mission. [However,] agency management at a too fine-grained level, involving frequent interference with day-to-day lab operations, excessive reliance on formal long-range planning rather than evaluation of past performance, attempts to direct R. & D. programs in detail from headquarters, and restrictive packaging of funding without delegation of reprogramming authority to the laboratory can be . . . wasteful of scientific resources and destructive to a laboratory. There is a real trade-off between keeping a laboratory "relevant" to its [sponsoring] agency's mission and assuring its ability to innovate and produce high quality research.⁵

The issue described under the heading "level of management" is one that affects different laboratories in different ways. For example, there are reports that Department of Energy laboratories are very sensitive to increasing involvement of DOE program managers at agency headquarters in decisionmaking on day-to-day laboratory operations. This is an intraagency manifestation of the problem of maintaining balance between sponsor control of research, and performer autonomy—a pervasive problem in modern scientific research. There is no such intraagency level of management problem at NBS. This is accounted for by one very simple fact: There are no Commerce Department program managers outside the laboratory for NBS work. At NBS, the immediate parent agency (the Bureau) and the laboratory are synonymous. NBS Commerce Department funds are budget items allocated directly to the laboratory. Although some NBS managers think that Commerce budget examiners have too much influence in overall program planning, operationally, the

⁵ "National Laboratories Issues," pp. 5-6.

autonomy this organizational structure provides NBS puts it in an enviable position vis-a-vis most other national laboratories. Scientists at various levels of the laboratory, working under internal ("STRS") funds can basically chart their own courses, subject to the NBS internal budget and program planning and review process, and external review by the NBS visiting committee, the NAS evaluation panels, and, of course, the scientific peers who judge their publications. They typically do not have to be concerned that an administrator elsewhere in DOC will second guess their technical judgment.

One could argue that this degree of autonomy has been largely responsible for the Bureau's strong esprit de corps and the excellence of its measurement-oriented research for which it is justly famous. In terms of administrative politics, however, there are some costs. In particular, it means that the Assistant Secretary of Commerce for Science and Technology, to whom the NBS Director reports, is the Bureau's only constituent within DOC. With respect to the internal DOC competition for funds, the other DOC bureaus are rivals to NBS, rather than its clients or allies. This is another way of saying what was noted earlier—that the NBS mission appears to be only indirectly related to the missions of the other units of the Commerce Department. In the absence of a strong external constituency, this puts the Bureau in a relatively weak budgetary position—the results of which are discussed throughout this report.

With respect to work NBS performs for other agencies, the situation is somewhat different. Approximately 43 percent of the NBS budget is derived from such sources. Program managers (or their functional equivalents) in the other agencies are the sponsors and have responsibility for these funds, while NBS scientists are the performers. Under such circumstances, conflicts over level of management may arise when NBS scientists and their non-NBS sponsors disagree on how a particular piece of work is to be carried out. Such conflicts are relatively rare, however. On the whole, relations between NBS performers and their other agency sponsors have been cordial and free of the kinds of tensions that are said to plague other laboratories. It has been pointed out, however, that NBS management has been strongly influential in the design of other agency programs in order to insure the integrity of NBS technical work. The small number of exceptions encountered were situations in which NBS scientists with considerable technical experience in an area found themselves reporting to nontechnical people in a new or crisis-beset agency—for example, the Federal Energy Administration (FEA) or the Consumer Product Safety Commission (CPSC).

In a more general sense, though, the level of management problem does arise. It is manifested in the policy dispute with OMB over the "lead agency concept"—a dispute that NBS people speak of with some anguish. The basic issue is: To what extent should research performed by NBS in support of another agency be controlled and directed by the sponsor (the lead agency), and to what extent should the performing organization (NBS) have the autonomy to define the direction of its own work. Since control is usually maintained by those with the funds, the issue boils down to a discussion of the mode of funding. The OMB position on this issue is that if NBS is to work on, say, environmental problems, even in the area of measurements and

standards, it should be funded entirely through EPA; if it is to work on consumer product safety, it should receive its funds from CPSC. The Bureau's technical capabilities are not at issue. OMB is concerned with assuring that the research supports program objectives. By giving the lead agency the funds to support the NBS work, OMB believes that program accountability is maximized. The Bureau which might otherwise be tempted to use the funds to explore questions of greater scientific interest, is forced to be responsive to its sponsor's needs. OMB also feels that this practice insures that the performer will recognize the timing and priorities of other agencies, will prevent duplication of work, and will allow OMB budget examiners to assess total programs.

NBS personnel have several objections to these OMB arguments, and their views on this subject seem to reflect a rather broad consensus among all levels and segments of the NBS community.⁶ First of all, it is argued, the lead agency may not always be right on substantive technical matters. While lead agency personnel might be closer to their mission, NBS personnel are generally closer to the technology. They object to the need to be responsive to sponsors whose technical judgment they regard as inferior to their own. Not only can this create inefficiencies in the work being done, but by decreasing the Bureau's scientific autonomy, it weakens management, injures Bureau morale, and sometimes causes shifts in personnel that may not be most efficient since funding and slots are not always forthcoming from an assigned lead agency. Furthermore, as discussed earlier in this report, giving the lead agency complete control over the funds reduces (sometimes to zero) NBS ability to build its competence and to pursue long-range studies—the importance of which may not be apparent to a sponsor beset by immediate problems and short-term needs—that distinguishes a creative scientific institution from a "job shop." The Bureau is strongly (and rightly) concerned about the need to avoid becoming a job shop. Additionally, this policy does not allow NBS to identify and work on measurements and standards they perceive as needed in areas, such as energy, unless the lead agency asks for and supports such work. This concept ignores the highly developed expertise of the Bureau in identifying existing gaps in measurement science and filling these gaps so that such information can be incorporated properly into Government functions, such as procurement and regulation.

As a division chief at NBS suggested, NBS could be considered analogous to the Nation's corporate laboratory for measurement sciences and standards. It is not a good policy to fund too much of it through operating divisions of the corporation (other agencies); their perspectives are simply too narrow. Major corporations know this and support their corporate laboratories largely out of general corporate funds, and he suggested that the Government ought to treat NBS in the same way, at least for this area.

It is not easy to suggest options for dealing with these issues. Earlier it was noted that the Bureau should be given direct funding for competency building for all its work, whether in support of its measurements and standards or its technical support function. In

⁶ The NBS position is presented in depth in "Implementation on NBS Measurements and Standards Responsibilities in the Context of the Federal Lead Agency Concept," a report to the NBS executive board by the NBS Ad Hoc Committee on the Lead Agency Issue (June 1977).

fact, a modest fraction of the fiscal year 1979 NBS budget has been placed in a reserve for competency building. Apparently, it is intended that this portion of the budget will grow in coming years, eventually reaching the level of 15 percent of the total NBS budget. This step should help NBS pursue internally defined studies relating to its other agency work if approved in the congressional appropriations process. If well managed by the NBS administration, it should do much to alleviate concern about the lead agency problem. Another approach which Congress might encourage OMB to experiment with in lieu of the lead agency notion is to provide funding directly to NBS for any mandated work with the stipulation that its responsiveness to the lead agency and overall performance on the work will be evaluated after a period of several years. Such evaluation would have to include the responsiveness of NBS to deadlines and priorities of the other agency. The threat of having funds taken away might be sufficient to accomplish OMB's objectives. The Congress could also experiment with legislative language which would specify that funds authorized to the Bureau for a particular piece of work, could not be reassigned to any other executive branch agency by the OMB to fulfill its lead agency concept, even if funneled back to NBS to perform the actual work. This would allow control of the funds at the Bureau.

In the case of service work requests by another Federal agency to NBS, it would seem reasonable for that agency to maintain control of the funds. NBS could, however, institute a competency-building tax on such work in its interagency agreements in order to build its abilities to provide even better services in the future.

SCIENTIFIC FREEDOM AND RESPONSIBILITY

One [complex] issue is the degree to which individual scientists can be guided by their own perceptions of organizational goals and national interest as opposed to the perceptions of their superiors. This is reflected at the laboratory level in the opportunity for research groups to pursue new ideas and raise new possibilities of analytical conclusions whether or not they run counter to agency policy . . . [there is also a related] situation which arises when a . . . researcher [or a laboratory] seeks to reveal valid information, but is prevented from doing so by administrative superiors.⁷

Perhaps the best known instance of bureaucratic conflict over an issue of scientific freedom and responsibility in recent American history involved the National Bureau of Standards. As a part of its product testing activities, the Bureau, in 1949-50, examined the efficacy of a variety of automobile battery additives, including one known as AD-X2.⁸ NBS research had indicated that AD-X2 possessed no special merits, a finding the manufacturer vigorously disputed. The manufacturer was able to obtain other, apparently contradictory test results, and gained the interest of a number of Senators and Representatives. The result was national publicity for the product, and the dismissal of the NBS Director by the Secretary of Commerce. Although the NBS Director was soon reinstated and the furor raised by the incident eventually died down, the battery additive controversy highlights a continuing set of concerns for NBS, an agency which

⁷ "National Laboratories Issues," p. 7.

⁸ This incident is described in detail in Samuel A. Lawrence, "The Battery Additive Controversy" (University, Ala.: University of Alabama Press, 1962). Rexmond G. Cochrane, "Measures for Progress: A History of the National Bureau of Standards" (Washington: U.S. Government Printing Office, 1966), pp. 483-487, also provides a description.

must reconcile the needs and values of science with those of commerce and industry.

Issues of scientific freedom and responsibility can be particularly complex and difficult in large organizations such as NBS. In view of the reputation of NBS for objectivity, scientific competence, and political neutrality, and in view of the Bureau's statutory position as the highest national authority on measurement standards, physical constants, and test methods for materials, one would expect it to be particularly sensitive to such concerns. The handling of the AD-X2 incident at the time, and subsequent precautionary measures on the part of NBS leadership, seem to have contributed to the fact that this issue arose only infrequently in the context of the present study.

This is not to say that concern over scientific freedom and responsibility is totally absent. As was the case in the battery additive controversy, in the realm of consumer product testing, the Bureau may sometimes find itself forced to make known findings that run counter to the immediate economic interests of elements of the Commerce Department's constituency.

Where the public interest lies and how it relates to the self-interest of the organization are not always clear. Nothing could be more harmful to the Bureau's ability to fulfill its mission than to have it constantly embroiled in controversy, particularly if the Bureau's scientific work was eventually shown to be inadequate or subordinated to short-term political interests. It is likely that this need is recognized throughout the Bureau, by bench scientists and administrators alike, and in the Commerce Department as well.

The recognition helps account for the relative scarcity of such incidents. Furthermore, as Assistant Secretary of Commerce Jordan Baruch pointed out to us, industrial firms generally acknowledge the technical competence and authority of NBS and thus do not often dispute NBS findings when they are based on NBS technical work. It is in their interest to have Government work in such areas as consumer product safety done well, and they recognize this.

Since the problem is not overwhelming, it would seem that options for alleviating it are not in order. Nevertheless, it is important that, in the standards area particularly, the Congress should insure that NBS positions are supported appropriately by resources for research and investigation. This is the best assurance of integrity for those positions. As an example of the potential problem, the ICST has been substantially inhibited by lack of resources to fulfill the requirements placed on it for automatic data processing standards development. As a result, ICST has been more vulnerable to external pressures—both political and commercial—concerning development of these standards.

ORGANIZATIONAL FLEXIBILITY

Large organizations, including mission-oriented national laboratories, are commonly believed to be most productive during the early years of their existence. As labs (and other organizations) mature, and their growth slows down or stops, staffs tend to age, the ambitious and more able people leave or lose their zeal, and organizational performance (particularly creativity and the ability to adapt to new environmental conditions) tends to suffer from increased rigidity in structure and patterns of behavior. Preserving or restoring organizational flexibility and countering the effects of organizational aging are key issues in current national laboratory policy.*

* "National Laboratories Issues," pp. 7-8.

The National Bureau of Standards is the grandfather of this country's national laboratories. When it was founded in 1901, the authorized staff complement totaled 14 positions. During the past three-quarters of a century, it has experienced periods of rapid growth as well as periods of stagnation and decline in staff size. The past decade has seen the Bureau's permanent full-time staff decrease by about 100 to its present level of approximately 3,000. One would suspect organizational aging to occur under such conditions, and indeed evidence of it abounds.

Organizational aging is widely felt among NBS staff members to be a very serious problem. It is reported by NBS officials that the average age of the NBS staff has increased by nearly one-half year per year for the past decade or so. This would conform to the pattern known to exist in other Federal technoscience agencies, such as NASA, which have experienced either steady state or declining staffing levels in recent years. At least part of the morale problem at NBS appears to be due to the staff remembering the "good old days," when they were younger and when funds and jobs were more plentiful. Staff turnover is low and has been quite low for the past few years. This may have stemmed from the relatively tight job market a few years back, when staff were almost forced to stay on for lack of alternatives. This led to an aging of the overall staff, and perhaps now the generally older staff (average age of the professional staff is 44 years) is less apt to search out new opportunities.¹⁰ Whatever the case, the fact remains that, relatively few people leave, and this means there are relatively few positions available for hiring new staff members. One individual in IMR reported that he joined NBS in 1969 and that his section has not hired a new permanent staff member since he arrived.

This low turnover can lead to a variety of problems. For example, as the National Academy of Sciences evaluation panel for IAT notes in its 1976 report, the lack of modern training in materials science and engineering among professionals in the Center for Building Technology has hindered interaction with counterparts in IMR and, the report implies, has reduced the effectiveness of NBS work on building materials.

Given the limited possibilities for staff growth at NBS (although some new slots are anticipated for fiscal year 1979), as well as the low turnover of scientists and engineers, and the nature of the civil service system, the staff aging problem appears to be a rather intractable one for the Bureau, as it is elsewhere in Federal laboratories. However, certain options might be available. Modifications in the civil service system might alleviate the problem in some ways. A senior scientific service, preserving tenure rights, but allowing for increased mobility of scientists among national laboratories might be one useful step. In fact, industrial laboratories, also faced with shrinking R. & D. operations, rely on the movement of lab personnel from unit to unit to maintain scientific and technical vitality. Development of a formalized system of term appointments (for, say 3 to 5 years) for Bureau scientists would also facilitate turnover. The NIH, for example, uses a floating pool of fellows to help maintain its vitality. These individuals are funded out of the regularly appropriated budget, but the slots are rotated to areas of greatest scientific need and interest. It might be useful for NBS to receive a steady allotment of term appointments

¹⁰ See appendix C.

to be handled in this "rotating" manner, in addition to its usual full-time permanent staff ceiling.

Short of such changes, one of the existing mechanisms the Bureau has available for bringing in new blood is its postdoctoral fellowship program, under which young scientists spend 2 years in residence at the Bureau, with a relatively attractive stipend (paid by NBS) and an allowance for supplies and equipment. The presence of these fellows, 60 percent of whom leave at the end of their terms to take permanent positions elsewhere, gives senior Bureau personnel the opportunity to work with bright young scientists who may bring with them fresh ideas and approaches to problems being explored at the Bureau. The Bureau's scientific reputation still appears to be adequate to attract high quality applicants for its postdoctoral appointments. Fellows from less renowned universities seemed pleased with their appointments, but Ph. D.'s from top-ranked universities did not seem to consider an NBS postdoc a "plum" in the sense this was true a few years ago. At any given time there are a total of 40 to 50 postdoctoral fellows in residence at NBS, although NBS has increased its program substantially for fiscal year 1979. While occasional concerns were expressed about the relations of their activities to the Bureau's programs, on the whole it appears that they serve a very useful function in maintaining organizational flexibility. Other devices used by NBS include bringing in research associates from industry, use of visiting professors, and some participation in executive exchange programs.

Another mechanism for promoting organizational flexibility is, of course, reorganization. Reorganization offers the opportunity to break down rigid lines of authority and communication. It provides a chance for new patterns of leadership to form and for previously disparate elements of the organization to establish relationships with one another. Some students of organizational behavior feel that periodic reorganization is useful for maintaining organizational flexibility, even if the new organizational design offers no particular advantages over the one it succeeds. Reorganizations have their costs, however, in the tensions they create, in the psychic energies they absorb, and in the extent to which they disrupt ongoing work. If reorganization is employed too frequently, and the agency begins to feel itself in a constant state of reorganization, these costs can far outweigh the benefits. In the case of NBS, the frequency of reorganization does not seem to be a problem, since the Bureau's overall structure has remained essentially unchanged since the establishment of the Institutes in the mid-1960's. One could argue that even if it serves no other purpose, the current reorganization may be useful to NBS as a means of promoting organizational flexibility.

An alternative to frequent reorganization is to institute a planned turnover in the upper management level. This could be similar to the "rotating chairmanship" sometimes used in academic departments. At least one national laboratory, the Fermi National Accelerator, utilizes this concept in the management of its major operating units, with what it feels is considerable success. The advantage is that fresh viewpoints as to how to operate and tackle problems are brought in. The disadvantages, however, may include a sense of discontinuity in the program direction on the part of the staff in the unit.

Since NBS is currently implementing a reorganization, it would seem reasonable to wait and see how it affects perceived flexibility, rather than suggesting the use of other options at this time.

As a positive point in the history of NBS approach to organizational flexibility, it might be pointed out that the Bureau has often been willing to divest itself of programs that have evolved to the point of being too large, or self-sustaining. For example, in the early fifties, the ordinance programs were removed and housed in a separate laboratory outside of NBS. Certain transportation-oriented activities were also transferred into separate units, and general service testing work for the General Services Administration was transferred out. The point here is that NBS has always maintained a willingness to take whatever steps necessary to keep its central mission from being overwhelmed, even if the cost was a shrinking organization. Perhaps this history could be considered as a little credit in the bank when staff limitations are distributed by DOC to its operating units under overall OMB personnel ceiling guidelines.

PRESSURES ON BASIC RESEARCH

There has been a trend throughout the scientific community in recent years to subordinate long-range, basic studies as well as exploratory and free-wheeling applied research not tied to closely-defined projects to demands for immediate solutions to pressing problems and demands for near-term payoffs on investments in R&D. Combined with the effects of funding instabilities, this situation, in the opinion of some observers, has significantly weakened our national basic research effort in a number of areas. According to this view, not only has it been injurious to morale and scientific output in the national laboratories, but this lack of fundamental research—for example, in the field of basic physical standards—may be impeding the course of technological development in such important fields as fusion and solar energy. The notion that technological progress is dependent on a storehouse of basic scientific knowledge, and that that storehouse must be continuously replenished, is hardly new. Nevertheless, in view of the pressures leading to reduction in basic research in the national laboratories, it bears repeating here.¹¹

Of all the issues confronting NBS, none seems capable of exciting more passions than the reported decline in support for basic research. A decline in Bureau resources devoted to basic research has been reported by the NBS visiting committee, by various evaluation panels, as well as by internal NBS committees. It has been cited in a variety of statements by NBS officials and visiting committee members, in congressional testimony, and in press accounts.

Generally the claim has not been quantified, although Ray Kammer of the NBS program office was quoted in *Science* with some numbers.¹² Kammer asserted that, while in fiscal year 1965, nearly \$7 million out of the Bureau's research budget of \$26.5 million (excluding other agency funding) went to basic research, in fiscal year 1978, the research budget had grown to \$70.4 million, while the basic research component had shrunk to \$3 million. Similar notions (although without such precise figures) were echoed numerous times in our interviews and discussions.

The validity of such figures is very difficult to prove or disprove. The figures are highly subjective and relatively easy to manip-

¹¹ "National Laboratories Issues," p. 9.

¹² Op. cit., p. 969.

ulate. They are sensitive to definitions of what constitutes basic research, questions of whose perspective is considered, and intentional misrepresentation of basic research as applied research for purposes of making it more "salable" in the budget process. While we therefore made no effort to verify the reported figures or to make quantitative measurements of basic research at the Bureau, we did explore the issue carefully and can offer several observations:

(1) The central point, that basic research at NBS has declined relative to other Bureau activities, appears undeniable. The addition of the many new, mandated programs, and the growth of work performed for other agencies without a proportionate increase in staff make this conclusion inescapable. No one with whom we spoke disputed it. The Bureau has responded to its new assignments by reprogramming staff and funds to meet their requirements. Under pressure to meet deadlines and show results in relatively short time frames, the Bureau, quite understandably, has cut back on long-term basic research for which there is no immediate external client or demand (as well as on certain applied programs that were either lower priority or problematic in some ways). The Congress, OMB, and the Commerce Department have implicitly sanctioned this mode of response by giving the Bureau new tasks without new funds or personnel slots in some cases.

(2) Bureau personnel tend to speak of the conflict between basic research and other activities as if it were a new issue, and often give the impression (whether intentional or not) that the situation is unprecedented in NBS history. In fact, the tension between basic research and other Bureau activities has been a continuing theme throughout the Bureau's history, related to the quality of the Bureau's mission:

Nothing could cause the institution to deteriorate more quickly than to flood it with routine testing. It must do a certain amount of original investigation to develop standards and methods of measuring or it will soon become a secondary institution.¹³

So testified Samuel W. Stratton, the Bureau's first Director, before a congressional hearing in 1908. Stratton was concerned that unless steps were taken to protect its research role, the Bureau would evolve into a routine testing laboratory. Similar situations have occurred over and over again in the Bureau's history, acquiring a particular poignancy in postwar and posteresis periods, when unusually strong short-term demands on the Bureau have driven out or overwhelmed basic research, and various forces have sought to restore balance. In 1953, for example, an ad hoc committee of the National Academy of Sciences charged with reviewing the functions and operations of NBS in relation to current national needs, reported that the Bureau's basic research had lost ground at a tragic rate to DOD and AEC sponsored weapons work.¹⁴

The nature of the NBS mission makes such tensions almost inevitable. The late 1960's and early 1970's have certainly been an era of crisis. In some respects the crisis has eased—or we have grown accustomed to living with it—and forces are at work throughout the scientific community to restore some balance between basic and applied

¹³ Cochrane, *op. cit.*, p. 92.

¹⁴ *Ibid.*, pp. 495–6.

research. This does not mean that the current situation at NBS is not serious. It does mean, however, that the current situation and assertions of "shocking gaps," "critical problems," and "unacceptable mediocrity," ought to be kept in perspective as recent manifestations of a continuing conflict.

(3) While opinion at the Bureau is essentially unanimous in reflecting a belief that basic research has declined from its previous level and is currently far too low, there is really no clear-cut basis for determining what the appropriate level ought to be. It is easy enough to say "more," but answers to the questions, "How much more?" and "Why that much?" are not all straightforward. While we have no direct answers either, a few guidelines are worth considering.

First, the ability to attract and retain first rate scientists (that is, to compete effectively for the best people with the top-rated universities, certain industrial laboratories, and other national laboratories) is one basis for judging the level of quality and the quantity of basic research at the Bureau. If top people no longer choose to come to the Bureau, or if those on the staff are leaving, this is one indication that the level of basic research is insufficient. The numbers of such persons do not have to be large for the effect to be significant. Perceptions, in this regard, are sometimes as important as reality. The Bureau's troubles have been widely advertised, undoubtedly in hope of gaining political support for their amelioration. Although this is not an unreasonable strategy for the Bureau and its friends to be following, there is a risk that by injuring the Bureau's reputation, the discussions could create a self-fulfilling prophecy.

Second, beyond the need to maintain scientific excellence at the Bureau, one needs to bear in mind the Bureau's unique and important role in certain specific areas of basic physical science. Much of the basic research the Bureau conducts in standards, measurement methods, and determination of physical constants, for example, is not likely to be done elsewhere, partly because it is not attractive enough to scientists in other types of institutions and partly because it is regarded as the Bureau's traditional domain. The Federal Government recognized this fact when it established the Bureau, and it has continued to do so by facilitating the Bureau's growth over the years. If the Bureau were to gradually withdraw from its traditional basic research role, the scientific community—nationally and internationally—could conceivably evolve other capabilities to take its place. But there is no question that progress in many areas of physical science and technology would be considerably retarded in the interim.

Third, the importance of the Bureau's basic research in providing the foundation for its applied research and technological development must not be overlooked. The need for building competence in such areas as measurement science and properties of materials through investigations not necessarily related to a specific, immediate application is genuine and critical to the Bureau. The quality of the Bureau's response to its applied mission depends on it. The notion that basic research creates a storehouse of knowledge upon which applied research and development draw has been widely discussed but is still not sufficiently understood by the general public and many political decisionmakers. Congress, OMB, and the Commerce Department, in judging the balance between basic and applied research at NBS, need to bear their relationship in mind and weigh it seriously.

REDEPLOYMENT/INTERGOVERNMENTAL USE

. . . The diversification of certain high technology labs to serve a variety of new missions and clients . . . [is one form of redeployment]. . . . The proper mechanism for redeployment—the circumstances where it works best through laboratory entrepreneurship and/or the circumstances where orchestration from [elsewhere] is more effective—constitute [a] set of key issues. . . . The limits of redeployment, the ways to distinguish a change in lab mission which serves a national purpose and yields high quality work from a change which simply serves to prolong the existence of an obsolete organization need to be examined.¹⁵

The concerns discussed in "National Laboratories Issues" under the headings of "redeployment" and "intergovernmental use," are extremely important to NBS. In fact, they have been discussed from different perspectives in several preceding sections of this report. The Bureau does more work for other Federal agencies than any other national laboratory. As noted earlier, some 43 percent of its budget is acquired in this manner. In addition, the mandated programs assigned to NBS by congressional action represent "redeployments," in the sense that they modify the laboratory's mission. Thus, in many ways the Bureau is a prototypical example of the potential and pitfalls of redeployment and interagency use.

The mandated programs pose some peculiar difficulties. Initially, one is struck by the extent to which Bureau personnel seem to regard many of these programs as burdens to be borne rather than as opportunities to be welcomed and exploited. There may be some feeling that certain of these mandates (for example, possibly the recycled oil program) are either not within the Bureau's mission or not very well suited to the Bureau's capabilities, or both. Although we were unable to investigate either the formal or the informal legislative histories of any of these programs, anticipated legislation is normally public knowledge for long periods before actual enactment. An active following of congressional bill submission would allow NBS to keep informed when reference might be made to the Bureau's involvement. Briefs could be prepared on each piece of legislation that seems likely to pass which would describe the Bureau's capabilities or inabilities to perform the proposed task; the likely impact on other Bureau programs; and any alternative means for accomplishing the work. Of course, NBS could not well anticipate any last-minute amendment during the final bill passage that might call on the Bureau's capabilities.

But in the other cases, if NBS and DOC were working hand in hand to insure that the Bureau's mission were maintained, as has been suggested before, then the Department could utilize these legislative analyses to work with committees to modify bills or suggest viable alternatives when proposed mandates appear unsuited to NBS capabilities. In fact, several representatives from the private sector mentioned that NBS is often doing work that could well be done outside the Government. Perhaps clear instances of this could be brought to the attention of the Congress, before legislation is passed. If Congress desires NBS involvement as a third-party observer, or watchdog, to insure the quality of results, this could be arranged simply by allowing NBS to contract the work out, while maintaining close monitoring.

Even with regard to the mandates that do seem to be generally viewed as well suited to NBS capabilities and mission, there are still

¹⁵ "National Laboratories Issues," p. 18.

problems—problems deriving primarily from the fact that they are externally imposed, without consideration of NBS internally defined priorities and without sufficient resources to cover their costs. The allocation of tasks and the allocation of resources, funds and personnel slots, seem to proceed along different tracks, with different sets of actors, different priorities, and few interrelationships between them. The new tasks are often burdensome because NBS is unable to carry them out without sacrificing part of its existing program. Since the Bureau feels it cannot compromise on the quality of its work, it often handles the mandated programs by, as IMR director Jack Hoffman put it, “‘taking our lumps’ on delays,”—stretching its efforts out. Many would argue that Congress should define the role for NBS, and that reordering of priorities is called for, if all programs cannot be met. This would not be denied, even by the Bureau. The difficulty is that NBS also has a charge to maintain its competences so that future needs of the Nation, as expressed by congressional directives, can be met. Perhaps a more cooperative approach in developing congressional program initiatives might help the Bureau acquire resources commensurate with the scale of its new assignments and still maintain its level of expertise for future work.

Outside of specific mandates, the Bureau of course does a large amount of work for other Federal agencies, including HUD, DOE, DOD, EPA, and others. In this respect, the entrepreneurial spirit flourishes in the Bureau. Motivation is clear and cuts across all levels of the Bureau. There simply are not sufficient appropriated funds (“STRS”) to support the Bureau’s entire personnel complement. The system seems to work reasonably well in most respects. A few problems are discussed above in other sections of this paper. A number of others might be noted:

(1) Although the balance between STRS and other agency (OA) funding does not look unreasonable in the Bureau as a whole, there are some who believe that the ratio of STRS and OA funding in certain parts of the Bureau is not good. This means that some divisions are much more strongly dependent on OA funding than others. Some apparently depend so heavily on OA money that they are forced to cross the line into job shopping in order to support their personnel during lean years. The planned reorganization seems likely to perpetuate this situation, at least in the applied areas, since it is reported that the new National Engineering Laboratory will be funded 70 percent by OA, while the new National Measurements Laboratory will only have 30 percent OA. The agreement on this topic is not unanimous, however, since many think that the more service oriented, applied side of the organization should have a preponderance of other agency funds.

(2) There were a couple of complaints by working scientists that the need to balance budgets at the division level sometimes leads division heads to shift STRS money away from people who had sufficient OA support. This penalizes those who are successful at attracting outside money and seems likely to reduce entrepreneurial incentives.

(3) The problem of personnel slots was mentioned repeatedly. It appears that NBS’ ability to take on desirable tasks for other agencies is limited by the availability of personnel slots. It might be noted that all other Government laboratories, and even private sector performers,

face staff limitations also. The only cause for concern is when service work, which has been required by statute in support of technical work for other agencies, cannot be adequately addressed by NBS.

Several options might be available although each seems to have drawbacks. First, DOC could allow the Bureau to temporarily exceed its personnel ceilings, although this might lead to the use of relatively untrained staff, or hurried completion of the work, in order to get back down to ceiling by the end of the fiscal year. Although the parent agency has the authority to do this, it is apparently not a common practice in order to respond to immediate and pressing demands. Second, the Bureau could arrange for the temporary transfer of skilled industry and university scientists into the laboratory to work, under the direction of a senior scientist, on the specific project. Whether such scientists would be available when required may be the barrier here. However, NBS could try to create an exchange program that was presented in attractive enough terms to those scientists in industry and academia who might be looking for a change of pace for a year or two. Third, NBS could contract out for such work. This would require congressional backing, at least in principle, since many NBS staff feel that such a practice might be viewed as ignoring the implied intent of Congress. Fuller consideration of this issue for the Bureau is presented later in this report.

It should be noted that the question of State and local government access to NBS was not explored in the context of redeployment. The Bureau has many contacts with State governments in its standards work. This work is highly praised and is, in fact, the source of one of the Bureau's strongest constituencies. It does not seem desirable to expand the NBS service role to State and local governments, outside of the measurements and standards area, in view of the volume of work it does for other Federal agencies and the limits on its personnel.

OTHER ISSUES

In the course of this study a number of issues arose which are of specific concern to the Bureau, but which do not figure prominently in the "National Laboratories Issues" paper. Primarily, these are matters relating to management problems which the Bureau faces.

(1) *Intramural/Extramural balance*

Many Federal agencies, when faced with personnel limitations and a growing set of responsibilities, have turned to outside R. & D. contractors to supplement their efforts. In fact we mention this as a possible option for NBS to use in providing technical service work to other agencies. Newer agencies, for example, NASA, the Air Force, and EPA, maintain large extramural efforts monitored by their in-house laboratories. The Bureau, on the other hand, makes only very limited use of outside R. & D. contractors, yet constantly decries the fact that personnel ceilings limit its abilities to carry out its assigned tasks. When asked why the Bureau did not use contractors more liberally, for example, in mandated programs, NBS officials generally replied that when Congress or other agencies made a request of the Bureau they specifically wanted the Bureau (with its unique skills) to do the work, not some outside contractor. There also seemed to be the implication that NBS scientists would be diverted from their own research by becoming involved too heavily in contract monitoring activities.

Recognizing that there is some validity to these concerns, one still cannot help feeling that the real reasons might relate more to organizational habits and traditions at NBS than to such rationales. NBS, like other old line Federal agencies existed long before the contract state took shape, and it developed its organizational culture and mode of operation before contract R. & D. was widely practiced. It would be neither feasible nor at all desirable to turn NBS into an administrative operation devoted chiefly to monitoring contracts. On the other hand, short of such an extreme, there is no reason that NBS cannot and should not broaden its use of outside contractors. Perhaps NBS could examine the experiences of other civil service laboratories in using outside contractors to perform high quality technical work. It was pointed out to us during early reviews of this paper, that NIH uses outside contractors with little difficulty and without generating the ill will of the Congress. NIH feels that the key is to make certain that the contract supplements an ongoing piece of intramural work. In that way, quality can be maintained. Many observers agreed that NBS should not display such reluctance to utilize the contract method, as long as it is kept in perspective and does not lead to excessive administrative burdens. In addition to allowing the Bureau to expand the scope of its efforts, such a policy might well help build the Bureau's external constituency and its base of political support. A rigid legislative requirement that the Bureau spend a certain percentage of its budget in extramural research is not a good idea, but some words of encouragement from Congress might be useful.

(2) *NAS evaluation panels*

The NAS evaluation panels serve a valuable function for the Bureau in broad program evaluation as well as in maintaining ties between the Bureau and the rest of the scientific community. It is a function other national laboratories (some of which have no formal evaluation process) would do well to emulate. Nevertheless, the fact that the panels are employed on a contract funded directly by the Bureau suggests at least the possibility (if not the reality) of a compromised relationship. Although the Academy maintains control of panel membership, suggestions are solicited from the Bureau itself. It has also been noted that the panels often become advocates and supporters for the units they review, and in that sense, function as friendly advisers rather than objective reviewers. It might be useful in this respect if the NBS Director and the Secretary of Commerce would clarify that the panels are to function as advisers to the NBS Director only in order to insure that the Director is running the best possible organization. This may not be easily accomplished operationally, but the current reorganization of NBS will require a shift in panel composition. Perhaps a change in policy can be effected at this time. At the very least, units being reviewed should not be at all responsible for the nomination of members to their review panels.

(3) *The Boulder laboratories*

The decision to establish a remote laboratory as part of the NBS was made shortly after World War II. At that time certain expanded capabilities were needed and an essential requirement for the site was the need to maintain a radio quiet environment. Even though sites close to Washington might have sufficed, an administrative policy on dispersal of Government activities away from Washington led to the

decision to locate in Colorado. Today many, but not all, of the ongoing functions of the Boulder laboratory could as easily be performed in Gaithersburg. However, some observers think it is possible that insulation from Washington and headquarters pressures is a factor in creating a high-quality work environment. The fact remains that Boulder works very well where it is and the costs of moving the laboratories—monetary, human, and political—make the idea nonsensical.

The management problems posed by a satellite laboratory 1,500 miles away from headquarters are, nonetheless, substantial. They probably will not be solved by attempts to manage the laboratory more tightly from Gaithersburg. The management philosophy, rather, ought to be one of providing Boulder with high-quality leadership, an important, well-defined mission not too closely integrated with Gaithersburg, and a substantial degree of autonomy. Some observers emphasize the need to treat NBS Boulder as a separate laboratory, with its own priority planning process, which must naturally integrate closely with the mission of its parent agency (in this case NBS Gaithersburg). Failure to allow this autonomy could lead to micro-management on the part of headquarters, with all its derivative problems.

It does not seem from our interviews that an excessive amount of program control had been imposed on the Boulder personnel by the IBS management, to which it used to report. However, the proposed reorganization should be examined carefully to insure that such problems do not arise in the future.

One aspect of the Boulder operation should be noted as a possible option for Gaithersburg. This is the highly successful Joint Institute for Laboratory Astrophysics, which is a joint project of NBS and the University of Colorado. This program is widely praised inside and outside NBS as a productive and an exciting place to work. Given the difficulties of maintaining staff flexibility at headquarters, it would be useful to explore such a joint program, but in another area of technical pursuit, with one of the universities near Washington.

(4) Decisionmaking structures

The issue of top-level decisionmaking structures—systems of priority setting, resource allocation, program coordination, and dispute settling—deserves consideration in any assessment of a laboratory. The laboratory's problems and its successes are often traceable quite clearly to the decisionmaking structure internal to the laboratory.

In that vein, it was apparent from our interviews that the Program Office at NBS had acquired a considerable amount of influence in top level NBS decisionmaking, and it was apparent that there was considerable dissatisfaction throughout NBS with its role. Given that NBS leadership often has to make difficult and necessarily unpopular choices based on the recommendations of the Program Office, it is bound to generate criticism. It does seem, however, that the Program Office has been more a part of the decisionmaking at NBS than would normally be the case for a staff function. This may have derived from the inability of the executive board to make technical decisions for a fairly long period. Although it has been suggested that nonprogrammatic representatives on the board were the basis for this inability, it could as easily be linked to lack of strong, consistent, coordinative top management at NBS. The directorship has changed hands repeatedly in the last decade, and was in a state of uncertainty for the

past 2½ years as well. It is hardly easy to maintain strong management at the top under these circumstances.

In any case, the directorship is now permanent and a reorganization is underway. It remains to be seen whether the leadership will now take strong control, whether staff functions will be returned to just that, and whether the executive board will function as a line management unit to assist the Director in making and implementing decisions.

Future oversight of the Bureau might examine whether events have improved or degraded the decisionmaking structure at NBS.

CONCLUDING NOTE

The Bureau is a strong and sound institution which has faced and overcome serious problems in the past. The extent to which current NBS difficulties reflect continuing themes in the Bureau's history is striking, however. The duality inherent in the Bureau's mission and the way that duality impacts on external and internal perceptions of the Bureau is particularly important. While the fact that the Bureau has overcome problems deriving from this duality in the past gives cause for optimism, at the same time it suggests a need to pay attention to the long-term issues discussed in this assessment.

This review of NBS situation reveals that the problems relating to its mission and role stand out clearly as the most important. They seem to underline many of the problems discussed under other headings, and they stem at least partially from the failure of both the Bureau and the Commerce Department to understand how their roles relate to one another. In the report, a number of ways are suggested in which these problems can be addressed. On another level, the broadening of the formal NBS mission by subsequent legislation has led to increased responsibilities and opportunities for the Bureau. It has also stimulated reprogramming at NBS in order to meet new mandates. NBS clearly needs to recognize its own responsibilities to national needs, as reflected in congressional priorities. But the Commerce Department and the executive branch as a whole must also recognize the various roles of NBS and support the Bureau in its efforts to meet all needs. The report offers several options for accomplishing this.

The difficulties of the Bureau in maintaining organizational flexibility were evidenced clearly in aging staff, low turnover, lowered enthusiasm, and other factors. The Bureau is not unique in having to deal with these issues, however, as organizational aging is endemic in the scientific and technical community. NBS has made some attempts to address this itself by increasing the flow of new (albeit temporary) blood, via postdoctoral and other similar programs. It does seem that additional options might be available—some of which would require congressional assistance, such as creating a corps of movable civil service scientists. Such action might have beneficial effects for other national laboratories as well as for NBS. These options are discussed in the report. The Bureau is also undergoing a reorganization at present, which could contribute to flexibility. This is the subject of a separate OTA report, but the impacts on the Bureau should be examined closely in the future, after a period of operation under the new system.

It is clear that there are indeed pressures on basic research at this laboratory. But, it should be stipulated that the basic research that NBS undertakes is in support of an overall applied mission. Therefore, the situation is not the same as, and should not be confused with, the discussions of declining basic research throughout the Nation, and especially in the academic community. Rather, the decline at NBS is reflected in the increasing inability to build or maintain the scientific and technical capabilities in order to meet its applied mission. Sometimes, the Bureau has been asked to assist another agency of the Government in an area for which it does not have sufficient expertise. The building of capability might require the conduct of basic research, in order for NBS to be in a position to provide the service requested. Many of the options discussed in the paper for clarifying the mission of NBS would lead to amelioration of this problem. It is clear, however, that the NBS also has a responsibility to examine its activities and to assure that only such basic research as supports its two major missions, that is, provision of measurements and standards and technical service work, mainly for other agencies, is underway or is initiated.

This examination also revealed serious difficulties for the Bureau with the lead agency concept as employed by OMB. Although bureaucratic efficiency may be enhanced by such a practice, the potential impact on future national needs can be significant. The lead agency notion does not allow the Bureau, the Nation's center of excellence for measurement science and standards, to anticipate measurement needs in such areas such as energy, environment, or health, or initiate long-range work unless asked to do so by a lead agency. This runs counter to the directive in the Organic Act that the NBS shall maintain and develop national standards of measurements and provide means for making such measurements in scientific investigations. The most effective option would be for OMB to revise its policy. The report also discusses other, less effective, means for dealing with this issue, short of OMB changing its own policies.

Other topics relating to NBS were also examined and it was suggested, for example, that NBS could make expanded, but cautious, use of outside contracting, with potential good effects. It is clear that the remote laboratory at Boulder requires a special management style and that it also provides an example of a model program, JILA, which could well be emulated at headquarters. The decision structure internal to the Bureau needs careful thought and tightening up, but it is hoped that the current reorganization may address this.

The several national laboratories issues relating to the National Bureau of Standards, which are discussed in this report, merit careful attention by congressional oversight committees. Also the establishment of a continuing dialog among NBS leadership, DOC administrators, the OMB, the Office of Science and Technology Policy, and the Congress, in examining the role of this unique laboratory could prove extremely rewarding for the future of the Nation.

APPENDIX A

PERSONS INTERVIEWED FOR THIS CASE STUDY

NBS GAITHERSBURG

Ernest Ambler, Acting Director.
Howard Sorrows, Associate Director for Programs.
Elaine Bunten, Program Analyst for Visiting Committee and Evaluation Panels.
John Hoffman, IMR Director (Director Designee of NML).
John Lyons, Director, Center for Fire Research (Director Designee of NEL).
Ray Kammer, Acting Chief, Budget Div. (Associate Director Designee of Programs, Budget, and Finance).
Donald Johnson, Program Analyst, IBS.
Zane Thornton, Acting Director, ICST.
Arthur McCoubrey, Director, IBS.
Jack Rush, Chairman of the Director's Research Advisory Committee.
Mati Tammaru, Chief of Personnel Div.
Lucy Hagen, Scientist and President of Standards Committee for Women.
Jenkins Washington, Architect and Chairman of EEO Committee.
John Simpson, Acting Chief, Mechanics Div., IBS.
Brian Belanger, Acting Chief, Office of Measurement Services, IBS.
Thomas Pyke, Chief, Computer Systems Engineering Div., ICST.
Flonnie Dowell, Post-Doc.
Wayne Shold, Post-Doc.
Peter Roitman, Post-Doc.
Donald Kanuss, Post-Doc.
Virginia Maxwell, EEO Coordinator.
Marshal Isler, Deputy Center Director, IAT.
Harry Rook, Section Chief, IMR.
David Didion, Section Chief, IAT.
John Evans, Section Chief, IAT.
Richard Wright, Director, Center for Building Technology, IAT.
William Kirchhoff, Acting Director, Office of Air and Water Measurement, IMR.
Harold Berger, Manager of Non-Destructive Evaluation Program, IAT.
Jack Snell, Director, Office of Energy Conservation Programs, IAT.
Paul Cali, Chief, Office of Standard Reference Materials, IMR.
George Lewett, Manager, Office of Energy-Related Inventions, IAT.
Melvin Myerson, Chief, Product Systems Analysis Div., IAT.
Robert Carter, Chief, Reactor Radiation, Div. IMR.
Vivian Parker, Chemist, IMR.
Sandra Greer, Physicist, IBS.
Melvin Linzer, Physical Chemist, IMR.
Bernard Mozer, Physicist, IMR.
Lawrence Kushner, Coordinator for Policy Development.

NBS BOULDER

Bascom Birmingham, Deputy Director, IBS/Boulder.
Richard Kropschot, Chief, Cryogenics Div.
Hal Boyne, Chief, Electromagnetics Div.
Robert Kamper, Associate Division Chief, Electromagnetics Div.
James Barnes, Chief, Time and Frequency Div.
David Hummer, Chairman of JILA.
Helmut Hellwig, Section Chief.
Charles Miller, Section Chief.
Jesse Hord, Section Chief.
John Hall, NBS employee at JILA.
Carl Lineberger, U. of Col. employee at JILA.
James Faller, NBS employee at JILA.
Stewart Novick, Post-Doc at JILA.
Mac Keiser, Post-Doc at JILA.
Kenneth Evenson, Physicist, Time and Frequency Div.
Norris Nahman, Engineer, Electromagnetics Div.
Douglas Mann, Engineer, Cryogenics Div.
Alan Clark, Physicist, Cryogenics Div.
Ramon Baird, Section Chief.

OTHERS

Gary Clark, NAS staff member for the NBS Evaluation Panels.
Jordan Baruch, Assistant Secretary of Commerce for Science and Technology.
Diane Cormier, Office of Management and Budget budget examiner for NBS.
Herbert Holloman, former Assistant Secretary of Commerce for Science and Technology.
Allen V. Astin, former Director, NBS.
Howard Neviser, Office of the Secretary, DOC.

APPENDIX B

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APPENDIX C

TABLE 1.—*Average age of NBS full-time permanent professional staff by year*¹

Year:	<i>Average age</i>
1972	41.0
1973	41.5
1974	42.8
1975	43.0
1976	43.1
1977	43.8

TABLE 2.—*Number of full-time permanent terminations and new hires by year*¹

Year:	<i>Terminations</i>	<i>Hires</i>
1972	102	61
1973	94	55
1974	85	56
1975	110	65
1976	69	43
1977	78	39

¹ Data supplied by NBS Personnel Division.

NATIONAL BUREAU OF STANDARDS

STATE OF THE BUREAU ADDRESS

ERNEST AMBLER, DIRECTOR

Colleagues of the National Bureau of Standards, this is the third time that I have reported to you on the state of the Bureau, twice as Acting Director and now as Director.

Last year I had to report to you on a difficult year. By contrast, this year has been more satisfactory. The President's budget for fiscal year 1979 requests from Congress the biggest increase for NBS ever. We have successfully completed a reorganization that reflects the major NBS functions and is structured to permit building for the future. And we have seen a strong concern develop for NBS on the part of the statutory visiting committee, the administration and Congress.

Starting in February 1976, we began presenting to the visiting committee analyses on the effects of new assignments being given to NBS, frequently without resources, coupled with a constant budget and slightly declining personnel ceiling. By the time of their meeting last September with Secretary Kreps they were ready to deliver a strong report indicating the need to reverse these trends. The Secretary's response was very positive.

Also, during the past year Congress has taken unprecedented interest in NBS. The House held oversight hearings on NBS on October 25. These were the first such hearings since 1971. Ted Peck, chairman of our visiting committee, Bill Baker, who heads the NAS advisory panels, Jordan Baruch, and I appeared as witnesses.

Congressman Thornton of Arkansas, who chaired the session, was sympathetic to NBS, understanding of our situation, and concerned about the disparity between our assignments and resources. He said, in opening the hearing:

We are interested in finding out what has tightened the drumhead of the Bureau to stretch your resources; whether there are areas, especially of short-term investigative work, where the Bureau's capabilities are being expended at the cost of other programs which might be more vital, and what additional resources would be required in order to accomplish the major objectives of the Bureau and to respond to the mandated assignments.

On December 14, my confirmation hearings were held before a Senate committee chaired by Senator Stevenson of Illinois. The questions asked by the committee, especially by Senator Stevenson, reflected a concern for the relationship between science, technology, and the Nation's economic health. At the conclusion of my confirmation hearings, Senator Stevenson said:

I hope that we can be more supportive of the Bureau and helpful to it than the Congress has been in the past. We have touched upon two subjects this morning, including the level of investment, both public and private in R. & D., and basic science, which are of great interest to me. . . . There will be opportunities, I suspect, for you to cooperate and I hope you have suggestions or ideas.

On February 15, of this year, Mr. Stevenson's committee held oversight hearings on NBS. In opening the session Mr. Stevenson said:

We are here today to discuss the Nation's oldest national laboratory. We can't figure out when the last oversight hearing in the Senate was held, if ever. We aim to remedy this neglect. Our objective is a strong NBS that continues to contribute to the scientific and technological capabilities of the United States.

At these hearings Jack Hoffman, John Lyons, Zane Thornton, and I made detailed statements about NBS programs and future directions. Mr. Stevenson asked over 40 questions, reflecting his interest in NBS and his broad concern with the impact of science and technology upon the economy.

On April 6, a second session was held before this committee, at which time Dr. Baruch presented his views about NBS and where it is headed. Dale Compton of our visiting committee, and Bill Baker, also testified.

Dr. Baruch said:

NBS has long been a first-rate institution. Its staff is exceptional and creative; its management is competent, growing in strength and dedicated to excellence. Together they continue to make valuable—indeed essential—contributions to our national well-being.

But we've been lucky, Mr. Chairman. We've been lucky while we've been mortgaging the future of the Bureau. For many years, I have watched the Bureau change. As a member of its evaluation panels and as a colleague, I have had close and frequent contact with the NBS management and staff. For the past year, that contact bordered on the continuous. What I have found is disturbing.

NBS has been stretched thin in recent years by a variety of new assignments and the lack of commensurate resources. We have mortgaged our future by avoiding investment in many areas of science and technology that will clearly become critical in the rapidly approaching future. We have met most of these assignments albeit with varying degrees of satisfaction both to us and to others.

Now, however, there is no slack left; no slack for developing our needed competence, no slack left for meeting new assignments and, most critically, no slack left for applying the capabilities of the Bureau to the Nation's rapidly growing need for technological help in its industrial development. The mortgage has come due. The President's budget request to the Congress addresses itself to this problem.

An unusual and most welcome appearance was made at these hearings by Congressman George Brown. In his testimony Congressman Brown, a member of the House committee that has oversight of our programs, showed great interest in and support for NBS.

Issues that he touched upon were the NBS mission, our relationships to other Federal laboratories and to industry, the adequacy of our resources, the characteristics of our staff, and our structure.

There have been many other congressional appearances by NBS staff during the year, as follows:

Yakowitz, Resource Conservation and Recovery Act; Snell and Warshaw, National Energy Act; Davis, telecommunications policy; LaFleur, Clinical Laboratory Improvement Act; Hoffman, energy/materials interface; Cali, environmental monitoring system; Lyons, Fire Prevention Study Act; Lyons and Tipton, energy conservation; Becker, recycled oil; and Hoffman, materials R. & D.

Also: Ambler, President's energy proposals; Ambler, House oversight; Ambler, confirmation; Ambler and Johnson, House NSRDS; Ambler, Lyons, Hoffman, Thornton, Senate oversight; Ambler, House Appropriations; Ambler, Johnson, Senate NSRDS; Ambler, Passaglia and Kropschot, pipeline safety; and Ambler, Senate Appropriations.

Preparing for these hearings takes a great deal of time, but it is time well spent. It gives us not only the opportunity to express our concerns for NBS, but also a chance to explain the importance of our ongoing programs.

If the House and Senate oversight committees decide in the future to hold periodic authorization hearings for NBS, as a bill currently drafted indicates, we will have a continuing opportunity to explain the vital importance of our work to the Senate.

The past year has been important also in terms of national science policy. President Carter is quite aware of the influence science and technology have on national goals. He said in his State of the Union message:

The health of American science and technology and the creation of new knowledge is important to our economic well-being, to our national security, to our ability to help solve pressing national problems in such areas as energy, environment, health, and natural resources. I am recommending a program of real growth of scientific research and other steps that will strengthen the Nation's research centers and encourage a new surge of technological innovation by American industry. . . . I am determined to maintain our Nation's leadership role in science and technology.

That commitment is already reflected in the 1979 Presidential budget. Our assistant Secretary for Science and Technology, Jordan Baruch, has done a tremendous job in gaining recognition and support for NBS. He has done this within the Department, with OMB, with Frank Press, the President's Science Advisor, and with Congress. We all should be proud and appreciative of his efforts.

A major theme increasingly reflected in statements by the administration and Congress is the importance of technology to economic growth. There is, of course, a strong connection between the two. The overwhelming concern with technology over the past 10 years has been with its adverse affects. Oil spills, air pollution, and airport noise have been common topics; unfortunately, jobs, productivity, choice in the marketplace, and standard of living have not received commensurate attention up until now. But the pendulum is swinging, and more balanced attention is being paid to the positive aspects of science and technology. There are compelling reasons for this shift. Materials shortages, energy costs, foreign competition, and other factors pose major challenges to American industry. While solutions are varied and complex, it is clear that technological innovation and diffusion are vital ingredients in almost every case.

Frank Press and Jordan Baruch are both convinced that this situation requires a much firmer appreciation of the Federal role than now exists. They have proposed a governmentwide interagency study called "A Domestic Policy Review" to determine if there really is a problem in the area of industrial innovation, and if so, what its dimensions are.

Jordan also feels that new partnerships between Government, industry, and universities can lead to improved innovation in the civilian industrial sector. On July 26, last year, many of you attended the session in the Green Auditorium at which Jordan outlined his preliminary thinking on this subject. There has been a continuing evolution of the concept called "Cooperative Technology", and I'd like to give you a brief status report.

The objective of the program is to cooperate with industry and academia in the development of technology supportive of industry.

This will be a Commerce Department level program, located in and coordinated by the Office of the Assistant Secretary for Science and Technology. This Office will be responsible for political aspects, policy development and priority setting, and for coordinating the activities of many units within the Department.

As presently conceived NBS would have several key roles. First, we would manage the feasibility studies that assess the merit of project proposals that come in from industry. If a proposal is approved, we would be responsible for the analysis of the proposals and managing the technical program that attacks a particular problem. In many cases the work would be done in outside laboratories.

The proposed program has many interesting features. The problems that would be addressed must come from industry, and industry would cooperate in the search for solutions. However, the program would be active rather than passive. Monitoring the state of technology in industry at home and abroad, and encouraging industry and academia to develop proposals responsive to the needs of U.S. industry would be important features. In each case there would be a targeted end-point for Government involvement. Finally, the supportive technology developed in the program would be available to all.

I want to emphasize that, at this point, cooperative technology is strictly a proposal. Funding has been requested in next year's budget with which to study the feasibility and desirability of such a venture. Howard Sorrows and a very small group at NBS are working closely with Frank Wolek, Jordan's deputy, in scoping out the dimensions of such a study. We shall report to you later as this concept develops.

One topic that affected everyone during the year was reorganization. I believe we are all relieved now that the new structure is in place, and that it went relatively smoothly. There were several objectives in carrying out the reorganization and monitoring these objectives will help us measure how effective it has been.

The first objective was to organize our technical programs along major functional lines into two laboratories and an institute. The effectiveness with which these units provide response to national problems, coupled with the increasing level of their prestige among peer groups, will be measures of success.

The second objective was to increase the efficiency of administration and management functions through consolidating program planning, budget and financial control in one organization, and consolidating all administrative services and support in another. These changes, coupled with raising all administrative functions to the division level, should allow for a more effective concentration by technical people on technical programs.

The third objective was to build for the future by consolidating competency, and planning for growth in important areas. Through competence building and optimum use of existing resources we expect to see an enhanced scientific and technical reputation for NBS, and also be in a position to tackle problems that the future will bring. We can already see this taking place in the Center for Electronics and Electrical Engineering and the Center for Materials Science, for example.

I believe the reorganization will be of particular benefit to the people at Boulder. For some years all of the Boulder operation was in the Institute for Basic Standards. While this arrangement helped solve a

number of administrative problems, in retrospect I feel that it had the undesirable effect of inhibiting Boulder from fully participating in new programs coming to NBS which were generally assigned to places other than IBS. Now, in the new structure, Boulder programs are represented in both laboratories and several centers. I feel this is a much healthier arrangement in that Boulder will better share in whatever prosperity NBS enjoys.

I've alluded to budget matters several times. I would now like to present the details of the fiscal year 1979 Presidential budget. This budget, which Congress is now reviewing, contains very encouraging news for NBS. This year our congressional base is \$70.1 million. Next year this base will be adjusted upward by a net amount of \$3,556 million. This is made up of an increase of \$5,575 million to cover such items as pay raises, increased utility costs and the like (in other words 8 percent to cover inflation) and decreases of \$2,019 million for non-recurring costs such as the money appropriated to modify building 226 for the fire program.

Also in base adjustments, there is a \$1.6 million addition for the recycled oil program that annualizes the fiscal year 1978 supplemental request for this program. Finally, there is a \$20.963 million increment for technical program expansion.

These dollar increases are accompanied by an STRS ceiling expansion of 93 slots. This, coupled with the other agency increase of 66 slots in fiscal year 1978, will provide 159 new slots to help alleviate the extreme personnel pressures we've been under for some years.

This slide shows a breakdown of the program increases. (I have already discussed cooperative technology.) While they are all important, in the time available this morning I shall only discuss two areas in detail.

The largest increment is \$13.4 million for ICST. This provides the first year increment of funding for a comprehensive approach to Brooks Act responsibilities of meeting the needs of the Federal agencies for computer information processing standards over the next 5 years.

This is a massive responsibility, and one that will present a stimulating challenge to our management capabilities at NBS. The Federal investment is over \$10 billion each year for computers, their associated software and the staff to run them. Despite the importance of the task, and our continuing efforts over the years to obtain adequate support, the total funding for ICST this fiscal year is only \$4.3 million. This low level of support has severely restricted our activities, and has led to both GAO and congressional criticism of our output.

We tried a new strategy in our ICST funding request for fiscal year 1979. First we put together a 5-year plan that presented a detailed, comprehensive approach to NBS activities in the standards area to meet Federal needs. In the future we shall be changing from a total reliance on the voluntary standards system, where a consensus has been very hard to obtain. We plan to use a Federal users committee to help us set priorities and then write standards ourselves or on contract with the private sector, whenever it becomes clear that the voluntary standardization system will not produce the standards we need in the time frame we have specified. In our strategy we also took a much more aggressive stance in explaining in detail to the Department and to OMB what we planned to do with these funds, and the consequences of not receiving them. Since OMB has both management and

fiscal oversight over the Brooks Act, and had received its share of criticism by Congress, they responded with approval for a major funding increase.

The next item is \$2 million for competence building. This is the single most important item in our budget. It reflects, on the part of OMB, concerns for the erosion of competence that I detailed earlier in my talk. Pending the outcome of an overview of NBS to be made by Dr. Press' office, a decision has been made to provide in the NBS budget a fund for maintaining competences and performing basic research in furtherance of the NBS mission objectives. The fund will be gradually built to a level equivalent to 15 percent of the NBS resources, both direct and reimbursable.

Competence building amounts to building the scientific and technical muscle of NBS. This will be done through the creation of new groups or strengthening existing groups devoted to long-term theoretical or experimental studies in science and technology. These groups, once established, would be responsive to the future needs of NBS and its clients for high quality scientific and technical work. Our goal is to create areas of excellence which have long lifetimes, but which are also adaptive to change.

The eight areas selected for competence building in fiscal year 1979 are shown on this slide.

One that has potential impact in almost every NBS center is mathematical modeling. Efficient, effective modeling could be used in such NBS work as fire research, fluid mechanics, chemical kinetics, product safety, and many more.

Closely coupled with improved mathematical capability is the need to greatly improve the NBS computing capability.

As almost everyone who used our 1108 computer knows, we are really stretching its capabilities. Our use rate is growing about 30 percent each year, a number that is even higher in the interacting mode. Turn-around time for batch work is now about 6 hours, and on April 24 we cut back on other agency runs in order to service NBS staff more efficiently. In addition, there is a growing demand from laboratory automation. Last October I created a committee to look into the situation and recommend a course of action. Their report, which was written after consultation with the special users group, the Research Advisory Committee, each MOU and each Boulder division, recommends a major upgrading of our capabilities.

Funding will be requested in the fiscal year 1980 budget for an initiative to provide modern, significantly expanded, computing services to NBS Gaithersburg and Boulder. Included in the initiative are increases in the technical support staff with emphasis on scientific computing support. Under this initiative, computer capability will be increased at least an order of magnitude, and interactive capacity will be increased three to four times over that available now. The precise way that this will be done is at present undetermined, and will depend upon a full requirements study.

Considering the fiscal year 1980 budget I am particularly interested again in competence building. Identifying areas in which competence should be built will require a close coupling to science, universities, and Government. Before we begin to build competence, we must know what the scientific and engineering opportunities and future directions will be, as well as those problem areas to which competence,

once developed, can be applied. Input from all of you, from the visiting committee, the evaluation panels, and the NBS Scientific Research Committee will be needed if we are to make the best selections.

In addition it seems to me that the situation today is very different from that when NBS last had the opportunity to build, which occurred right after World War II. At that time many new areas of science had been opened up and provided great opportunities. Today most of the interesting problems seem to me to have a strong multidisciplinary aspect to them. Therefore, the way we go about competence building might well be very different today. I invite you to think about this and let me have your opinions.

A principal source of ideas will, of course, be the NBS scientific and engineering staff. For some time I have felt the need for a forum in which NBS scientists could discuss their projects and ideas with me and other NBS senior management in a scientific rather than a program-review atmosphere. At first the Program Office took on this task, and has put together the first two symposia in what will be a continuing series. The first, scheduled for June 12-13, will be on microcomputer based instrumentation, and the second, on September 7-8, will cover atomic and molecular science and technology. It was not my preference that the Program Office should take the lead in this, but I used them to get things started. Now, I am happy to report that the Research Advisory Committee, chaired by Jack Rush, has volunteered to take this up and they will be arranging subsequent meetings in this series. If you have ideas and suggestions for these symposia you can contact any member of that committee.

There was one bit of bad news concerning the budget, and that was in the area of air and water pollution measurements. OMB took the position that such work was the direct responsibility of the Environmental Protection Agency, and no direct funding should be given to us for such work. We made a strong appeal of this decision, which was denied, and we are now working directly with EPA to insure their support for this work.

Let me now turn to the subject of equal employment opportunity. As a further step toward effective management and affirmative action we shall conduct, starting this year, EEO program reviews by each major unit in an open forum. We shall not only be reviewing programs, but also identifying barriers to increasing the numbers of minorities and women at NBS. Two items are especially important to me, namely our recruiting activities and the training of our own people. These seem to me to be crucial to our success.

In reviewing the situation, however, I am convinced there is more we can do.

Let us look, for example, at the statistics shown on this slide. In column 1 I show the number of full-time positions at NBS in four categories: physical scientists and engineers, technicians, administrative and clerical, and wage grade. Shown also are the percentages of women, blacks and Hispanics working in the various categories, first at NBS and second for the Federal Government as a whole. Except for Hispanics the numbers are comparable. The most significant feature, however, in my opinion, is that in the first category only 6 percent are women, 4.1 percent black and 0.5 percent Hispanic. Not only is this the largest single category at NBS, more important it is from this group that the senior technical management of NBS is developed. We

must improve our percentages here. But there is a difficulty that we must face squarely and honestly. There is a relatively small pool from which to draw and competition to hire from that pool is intense. Specifically in the national population in this category, 3.5 percent are women, 1.1 percent are black and 0.7 percent are Hispanic. For example, for the years 1974-75 out of about 10,000 graduate students in physics, 120 were black and 30 were Hispanic.

We must find a way to help increase this flow and channel more of it into NBS. Accordingly I am going to propose a budget initiative for fiscal year 1980 that would allow NBS to pay for a full course of graduate education in these fields. This would be available both to our own people and to those who would commit themselves to work here 3 years for every 1 year of training.

These two items, program reviews and a budget initiative are additions to our ongoing EEO programs.

Let me now turn to accomplishments over the past year. I would like to discuss a number of things that have come to my attention that are noteworthy.

In the formation of photochemical smog the interaction of ozone with olefins, such as ethylene and propylene, plays a central role. This situation is illustrated in this slide taken from the November 1977, issue of Dimensions. Until recently none of the intermediates have been identified in going to the final products, of which the aldehydes and several suspected radicals are the bad actors.

The formation of formaldehyde was known, but the fate of the peroxyethylene radical was thought to generate further radicals that could form a chain reaction in generating more smog.

Suenram (pronounced Syrom) and Lovas have shown, using microwave spectroscopy, that dioxirane is an essential intermediate. This molecule had been postulated theoretically but never observed.

Suenram and Lovas have proved its existence.

A parallel experiment by Martinez, Herron, and Huie, (pronounced Huey) using mass spectrometric techniques, have confirmed the existence of dioxirane and also shown the decomposition ratio to the final products shown on the slide.

Thus the fate of the chain following the formation of the peroxyethylene radical is benign insofar as smog production is concerned.

This work has been picked by researchers at EPA to model this facet of the ozone-olefin reaction. The new model, incorporating NBS results, gives a greatly improved agreement over previous models that contained hypothetical free radical chains.

Refractory metals such as Mo (molybdenum) are used as wall materials in magnetic fusion research devices such as Tokamaks, and thus occur as impurities in these plasmas. Radiation from the highly ionized impurities is a major source of energy loss from the plasmas. Thermonuclear burn will be difficult, if not impossible, unless the amount of these impurities is small and controlled. Control of the impurities relies on spectroscopic diagnostics of these elements. Until recently the spectra (and energy levels) of the high ionization states of these elements were not known.

Part of the difficulty has been that with spark source excitation many states of ionization are produced with complex spectra. The bottom two lines (which are actually for a silver spectrum) give you an idea of the line density and consequent problem of analysis. Reader,

Acquista, and Luther have shown that, by varying the pulse length of high power lasers, that is, controlling the rate at which energy is fed into the target, much greater selectivity can be obtained, as shown in the top line.

Using this technique and lasers at NBS, NRL and Los Alamos, these scientists have identified resonance lines of Mo^{+13} , Mo^{+30} , and Mo^{+31} all in the soft X-ray range. The importance of this work is twofold.

First, it's an exciting new experimental technique that is applicable to a large number of atoms. Second, it measures the spectra of atoms whose spectra resemble one electron type atoms. These simple spectra are indispensable for diagnosing fusion-type plasmas.

During the past year the first in a family of peripheral interface standards was developed by Tom Pyke's group in ICST. Such standards are essential if computer mainframes or central processors manufactured by one company are to be successfully interconnected to peripheral equipment, such as magnetic disk and tape drives, manufactured by any other company.

This slide shows one of the four connectors used at this interface. The technical specification of this interface itself includes the electrical and functional characteristics of the interface, so that manufacturers will be able to build equipment to go on either side of the interface, and users will be able to have confidence in the results when this equipment is interconnected.

Through an iterative process involving public review of our first proposed Federal interface standard, ICST is now moving quickly toward what we expect to be a milestone in the Federal computer standards program.

Wineland, Drullinger and Walls have demonstrated a way to cool ions held in an electromagnetic trap. It had already been shown that ions, such as singly ionized magnesium, could be held for hours in such a trap at room temperature. In order to reduce the first and second order Doppler shifts and reduce resonance linewidths it is necessary to cool the ions. In the first successful experiments last month, Wineland cooled magnesium to a temperature of about 50 kelvins and believes he can go much lower. The method is an ingenious one and relies on radiation pressure.

Imagine an ion A moving toward a photon beam (top left-hand corner). The ion will be resonant at a frequency $H(\nu_0 - \nu_D)$, less than the resonant frequency in the ion's rest frame. An ion moving in the same direction as the photon beam (top right-hand corner) will be nonresonant with the photon beam because the Doppler shift is in the opposite direction.

After absorption (bottom left-hand corner) the ion is slowed because of recoil. In subsequent photon emission there is no preferred direction, so that the emitted radiation can be anywhere within the Doppler envelope, and, on the average, will have energy $H\nu_0$, the unshifted resonant energy.

The net effect, therefore, of irradiating the ions with a frequency slightly less than the resonant frequency of the ion in its own rest frame, is to extract kinetic energy and therefore cool the ions.

Ernie Kessler, Deslattes, Henins, and Sauder have succeeded in measuring standard X-ray wavelengths to energies over 1 megaelectronvolt. They were able to transfer the lattice calibration of silicon standard X-ray wavelengths to energies over 1 megaelectronvolt. They

were able to transfer the lattice calibration of silicon crystals used in the famous experiment on Avagadro's number to larger crystals that could be used to measure Bragg angles for the X-rays in question.

At these X-ray energies the Bragg angle is only a fraction of a degree, so to obtain better than parts per million accuracy, angles needed to be measured to one one-thousandth of a second accuracy, which was actually done by obtaining closure on 360° , a considerable feat in precision measurement.

The new X-ray wavelength determinations which you see here have already made possible the reconciliation of experimentally determined energy levels in muonic atoms with quantum electrodynamic calculations. They have also helped resolve small discrepancies in the pion mass.

It is most encouraging to view the chain of comparisons that have been made at NBS, starting with the Cs-clock time standard and working up through the HCN, CH_4 and $^1\text{I}_2$ lasers, thence to the lattice spacing of licon and now up to gamma rays of 1.4 megaelectronvolt.

On liquefied Natural Gas (LNG) ships the volume versus height tables of the ship's tanks are used as the primary measurement system for custody transfer. Since such transfers are often international, NBS was asked to verify the accuracy of these tables for ships now under construction in Virginia. The tanks in these ships are 10-sided prismatic solids about 30 meters long, 30 meters wide, and 25 meters high. This slide shows the inside of such a tank.

Haight, Hartsock, Borchartt, Hocken, and Veale have developed a totally new technique derived from their experience in 3-D metrology, and measured several tanks in the first ship.

The technique consists of using laser instruments to generate an ideal solid with flat walls just inside the real tank. The vertices of this solid are marked on gage plates rigidly attached to the tank walls and distances from the real walls to planes of the ideal solid are measured at a large number of points. The difference between the dimensions of the real tank from the ideal solid is then measured.

This figure shows the deviations of the bottom of the tank from the ideal bottom plane. These are then used to compute accurate differences between the real and ideal solids. Since the ideal solid is known accurately, the real volume is also known accurately.

The technique is unique in the field of macrometrology. It characterizes the total 3-dimensional tank, includes redundancy for error checking, allows straightforward transformation of volumes for ship list and trim. Preliminary estimates from the algorithm closure give a 3σ volume error of a few parts in 10^4 , 10 times better than previous methods.

The mixing of materials in fluid flow is extremely important as, for example, in combustion. A new technique has been developed by Chabay, Rosasco, and Kashiwagi which measures concentration fluctuations and average concentration of individual species within turbulent gas flow.

In this technique the time dependence of the intensity of the Raman scattered radiation characteristic of a given species is measured. Since the intensity is linearly proportional to the concentration, changes in intensity are a direct measure of the fluctuations in concentration. This new technique was demonstrated in an experiment illustrated in this slide (diagram of apparatus). A laser beam was

focussed at a point within a stream of gas (methane coming from a 5-millimeter-diameter tube, surrounded by air coming from a concentric 25-millimeter-diameter tube). Raman scattered light excited at the focal point of the laser ($3 \times 10^{-5} \text{ MM}^3$ in volume) was imaged onto the slits of a Raman spectrometer, permitting detection of selected species.

The time dependence of the Raman intensity was analyzed by fast Fourier transform techniques to yield the fluctuation spectrum shown in the next slide. The height of the central peak indicates the average concentration of cold methane in this case. The three spectra show increasing fluctuation amplitude and frequency progressing from the red curve to the green as the gas flow was probed progressively downstream.

An important potential application of this technique is the simultaneous measurement of the fluctuation spectra of methane and oxygen, for example. This would allow determination of the efficiency of combustion in each region of a flame. Similarly, fuel and nitrous oxide concentration fluctuations in a flame could be simultaneously observed to assess pollutant formation rates and dependence on combustion efficiency.

Koyama, Buehler (pronounced Bewler), and Smith have developed a unique variable-temperature silicon wafer probe shown on this slide.

By quickly raising the temperature from that of liquid nitrogen to room temperature, they can measure a sudden change in capacitance of each of the 100 or so devices on a single wafer. The capacitance jump occurs when the trapped carriers are thermally emitted from defects, in this case gold atoms.

This slide shows the variation in gold concentration. The concentration ranges from 0.4 parts per billion (lightest regions) to 1.6 parts per billion (darkest regions).

Now for fast transistors, such as are used for example, in computers one needs high gold concentration for high speed, whereas for powers thyristors an intermediate level of doping is required to obtain an optimum design which balances speed against internal power dissipation. Therefore, using this new technique an engineer is able to tailor his design and subsequent processing to meet requirements for a particular application.

This technique is one of a large number of tools for process control that are being developed by the Electronic Devices Division. They are being used by industry to improve productivity. As industry is moving to very large scale integration and consequent complexity of manufacture these tools will be increasingly indispensable.

These selected highlights, as always, reflect the widespread technical excellence of NBS. It is particularly encouraging to me that work of such quality was done during the past year, which was a period of uncertainty and very tight resources.

Now that the situation gives promise of improving, and we are receiving both recognition and increased support, I look forward to an even brighter record of accomplishment. For example, the program to rebuild competence will create new centers of excellence throughout NBS. The accomplishments of these groups will enhance our esteem among peer groups and our reputation for responsiveness on the part of the administration and Congress.

In the area of ADP standards, the increased funding with which to really plan, manage and execute a major program is both an endorsement and a challenge. An endorsement in that OMB and Congress recognize our potential for making a major contribution in this area and our ability to effectively manage such a sizable increase in funds. The challenge results from the magnitude, urgency and technical complexity of the task. We will have both mandate and resources in this area, and the opportunity to formulate and operate a program of major impact.

The economic health of the Nation depends to a large degree on the use of science and technology. While all NBS efforts have economic relevance, the proposed cooperative technology program is specifically designed to provide direct industrial support. I'm excited by the Bureau's opportunity to help formulate and eventually participate in this program. Cooperative technology could break new ground in the area of Government-industry relations in this country and could well result in answering the challenges from overseas.

In sum, my view of the future is optimistic, and one that will encourage change and not complacency. With the interest and support of the visiting committee, Jordan Baruch, Secretary Kreps, OMB, and Congress; with a major reorganization that gives new focus to our efforts; with major scientific and technical challenges in every area; and with an excellent staff committed to quality output, I am confident that great years lie ahead. I hope you share my vision, for it is you who will make it reality.

NATIONAL BUREAU OF STANDARDS

REORGANIZATION

EXPLANATION OF THE PROPOSED CHANGE

I. The nature of the change

The proposed reorganization of the National Bureau of Standards consists of the following major changes: (1) Abolishing the institutes (except the Institute for Computer Sciences and Technology), (2) establishing two laboratories as major line components of NBS, (3) abolishing the Office of the Associate Director for Information Programs, (4) consolidating the central administrative and technical support functions of NBS from three into two main components: the Office of the Associate Director for Programs, Budget, and Finance and the Office of the Director of Administrative and Information Systems, (5) establishing centers rather than divisions as the organizational components reporting to major organizational units and providing local administrative support to the technical staff, and (6) transferring the functions of the Office of Experimental Technology Incentives Program into a newly created Center for Field Methods in the National Engineering Laboratory.

The change also anticipates studies of the need and desirability of a DOC cooperative technology program and the subsequent establishment of a National Center for Cooperative Technology. The Center is intended to use the process of the DOC cooperative technology program to address technological problems of civilian industries, domestic and international commerce, and State and local governments. The process may involve activities such as collaboration with industry, universities, and other agencies of Government in monitoring the state of technology and its infrastructure; in the identification and analysis of needed technologies and their potential impact; the development of methodology for the evaluation and management of joint industry/government tasks; and in performing joint technology development.

In addition to the changes and consolidations at the top of the NBS organizational structure, an entire organizational layer, the section level, will be abolished. Sections, the smallest organizations at NBS, will cease to be formal organizations under the proposed plan but will remain as informal working teams. Personnel will be formally assigned to divisions rather than sections.

II. Reasons for the change

A. Need to strengthen and maintain competence.—One of several problems with the current organizational structure that led to development of the proposed structure was an unsatisfactory balance of emphasis between solving immediate technological problems and strengthening and maintaining a high level of scientific and engineering expertise in the organization as a resource for solving problems. A gradual erosion of this critical resource has come to be recognized as a problem for NBS. A part of the NBS response to this problem is to establish an organizational structure designed to strengthen and maintain core technical competence. The two laboratories under the new structure and the centers reporting to them are assigned this important responsibility in order for them to carry out their mission, which is the delivery of measurement, standards and data services. The proposed laboratories are well suited to this task because they have the expertise to develop needed scientific and engineering personnel.

B. More timely response to national needs.—Under the institute structure, competition for resources has tended to reduce their flow across organizational lines when this movement is needed, and has tended to bring about reduced contact between groups engaged in related efforts. Hence the current structure is sometimes slow in responding cohesively to new and urgent technical tasks in the national interest. The consolidation of the organizational structure into two laboratories and the possible establishment of the National Center for Cooperative Technology are intended to respond to this problem by reducing dysfunctional competition for resources and by establishing institutional mechanisms for moving resources across organizational lines and for initiating new problem solving efforts that are responsive to national needs.

C. Consolidation of programs and administrative support.—Several of the new technical centers to be established under the proposed reorganization constitute consolidations of interrelated technical programs. An example is the Center for Electronics and Electrical Engineering, which brings together technologically oriented programs dealing with electricity in the Electricity Division, IBS Gaithersburg, the Electromagnetics Division, IBS Boulder, and Electronic Technology Division, IAT.

Administrative and technical support to the NBS staff were formerly managed by three Associate Directors: for programs, for administration, and for information programs. Under the proposed structure there will be two main organizations, the Office of the Associate Director for Programs, Budget, and Finance and the Office of the Associate Director of Administrative and Information Systems. Under the latter, the centers are designed to provide a manageable span of control over 12 organizational units and to integrate increasingly interrelated functions such as computer systems, library information systems, administrative information systems, and word processing for technical publications. The administrative centers are also being established in order to provide a framework for greater attention to delivery of services to users and responsiveness to user needs, and to provide a mechanism for the reallocation of resources across organizational lines (for example, between divisions) for programmatic purposes. In the current

structure, programmatic integration is difficult because of the large number of small units reporting to one manager.

D. Providing a framework for the cooperative technology program.—The new Department of Commerce cooperative technology program, when approved, will need a defined organizational structure to accommodate expected increases in staffing and funding and to provide the managerial framework to carry out the purposes of the program. These purposes are to provide for innovative applications of technology to industrial, intergovernmental, and international constituencies, to provide a focus for cooperation among these constituencies in developing new knowledge, prototype technology, and institutional mechanisms to promote the development of technologies where the private sector acting alone cannot or will not serve essential technological needs.

The proposed organizational structure for the National Center for Cooperative Technology is oriented toward the three main constituency groups outlined for the program: industry, governments, and international groups. The structure will thus be programmatically aligned to maximize responsiveness to constituency needs, whereas the laboratories are structurally oriented more toward areas of scientific and engineering competence, in keeping with their distinctive mission. The two sets of structures will constitute a matrix management system with technical competence as a resource along one axis and problem identification and problem solving activities along the other axis. Funds flowing into the Center for Cooperative Technology will be used to draw on the resources developed and maintained in the laboratories. The labs will also continue to function as a resource for numerous other Federal agencies in solving specific measurement and technology-intensive problems.

III. How the proposed structure was developed

The proposed organizational structure was developed with intensive participation by affected NBS managers and administrative staff, and the planning process called for suggestions and information from all staff members. When the Acting NBS Director initiated the planning, a tentative, broad outline structure and certain policy guidelines were promulgated. Five task forces of managers and administrative support personnel were established to develop more detailed organizational plans in the context of the overall guidelines. A central steering committee was established to review the products of the five task forces, resolve any differences between them that could not be resolved by joint meetings, and decide on the final proposal. The steering committee consisted of the Director, the chairperson of each task force, and the chiefs of the Personnel and Management and Organization Divisions. The five task forces were concerned with the programs, and internal structure of (1) the National Measurement Laboratory (2) the National Engineering Laboratory, (3) the Cooperative Technology Center, (4) administration, information systems, and facilities, and (5) the program analysis, budget, and financial management functions. A task force to develop a plan for the Boulder Laboratories was later established.

The makeup of these task forces and the general plan of the reorganization were announced to the entire staff and their suggestions were solicited as inputs to the work of the task forces or to the Management and Organization Division. Members of the NBS EEO

committee, the Standards Committee for Women, and union representatives were consulted during the planning process. Memoranda to the staff and special reorganization bulletins were used to clarify policy and to report progress. The NBS newspaper, The NBS Standard, carried a detailed lead article on the preliminary plans for the reorganization and the process by which further planning would occur. Additional bulletins and Standard articles and frequent meetings with the staff will be employed during the process of implementation.

Another vital input to the plan consisted of consulting with the NSB user community through the visiting committee and members of the National Academy of Sciences. These groups contain representatives of most of the groups who are users of NBS services.

Such a comprehensive reorganization would not have been possible without the inputs and efforts of numerous NBS staff members and representatives of the user community. Because there has been extensive participation in the planning, disturbances to morale are expected to be minimal, and effective implementation is likely.

BUDGETARY IMPACT

No increased costs to NBS are expected to accrue from the reorganization. Over time, savings can be achieved through consolidation of administrative functions. Because of commitments to minimize job losses, savings may not be realized immediately.

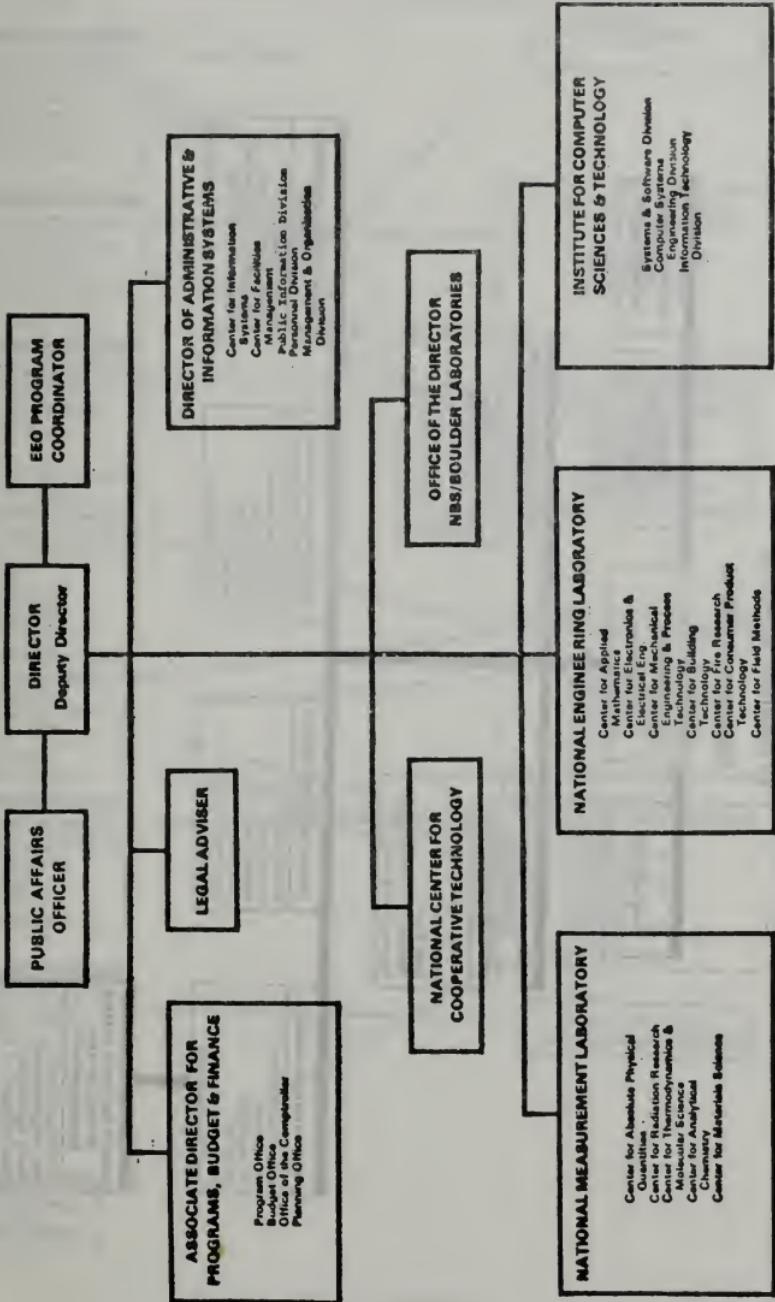
Changes in programs with consequent changes in resource needs are a result of programmatic decisions independent of the reorganization. Specifically, the request for resources for a new cooperative technology program was a consequence of programmatic decisions made by the Assistant Secretary for Science and Technology and approved by the Secretary of Commerce prior to and independently of this proposed reorganization. It, therefore, does not in any sense represent a cost of the reorganization.

STAFFING IMPACT

No significant increase in grade levels of NBS staff are anticipated as a result of the reorganization. However, there may be increases due to programmatic decisions on the DOC cooperative technology program and the proposed establishment of the National Center for Cooperative Technology.

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

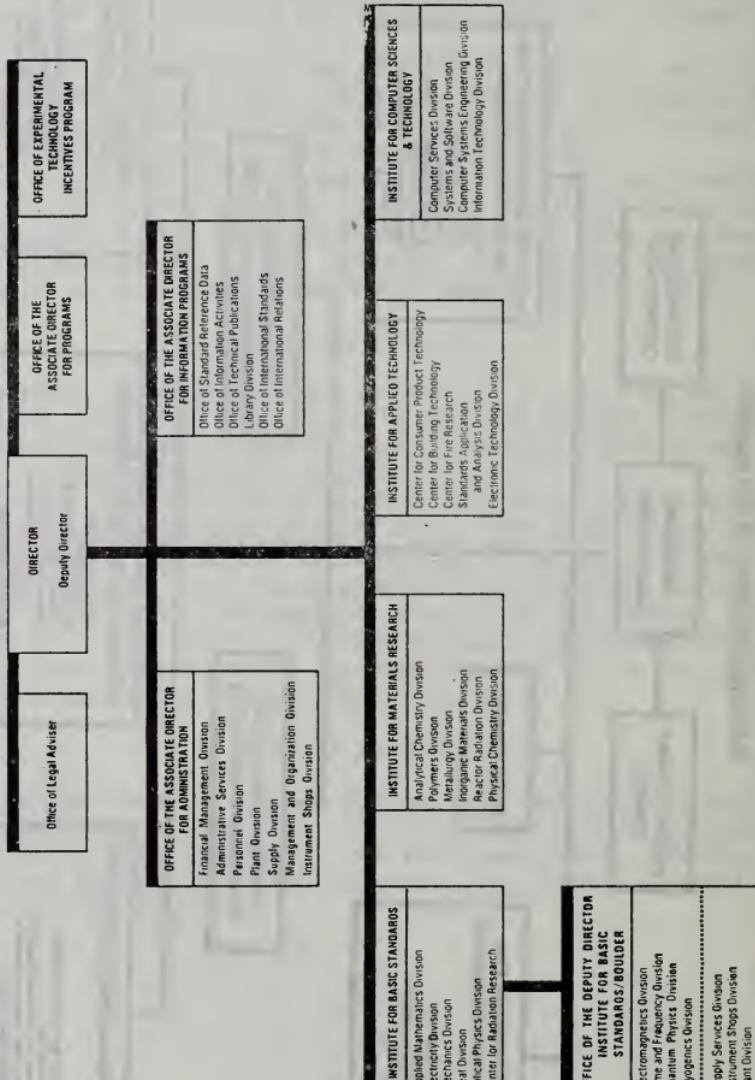
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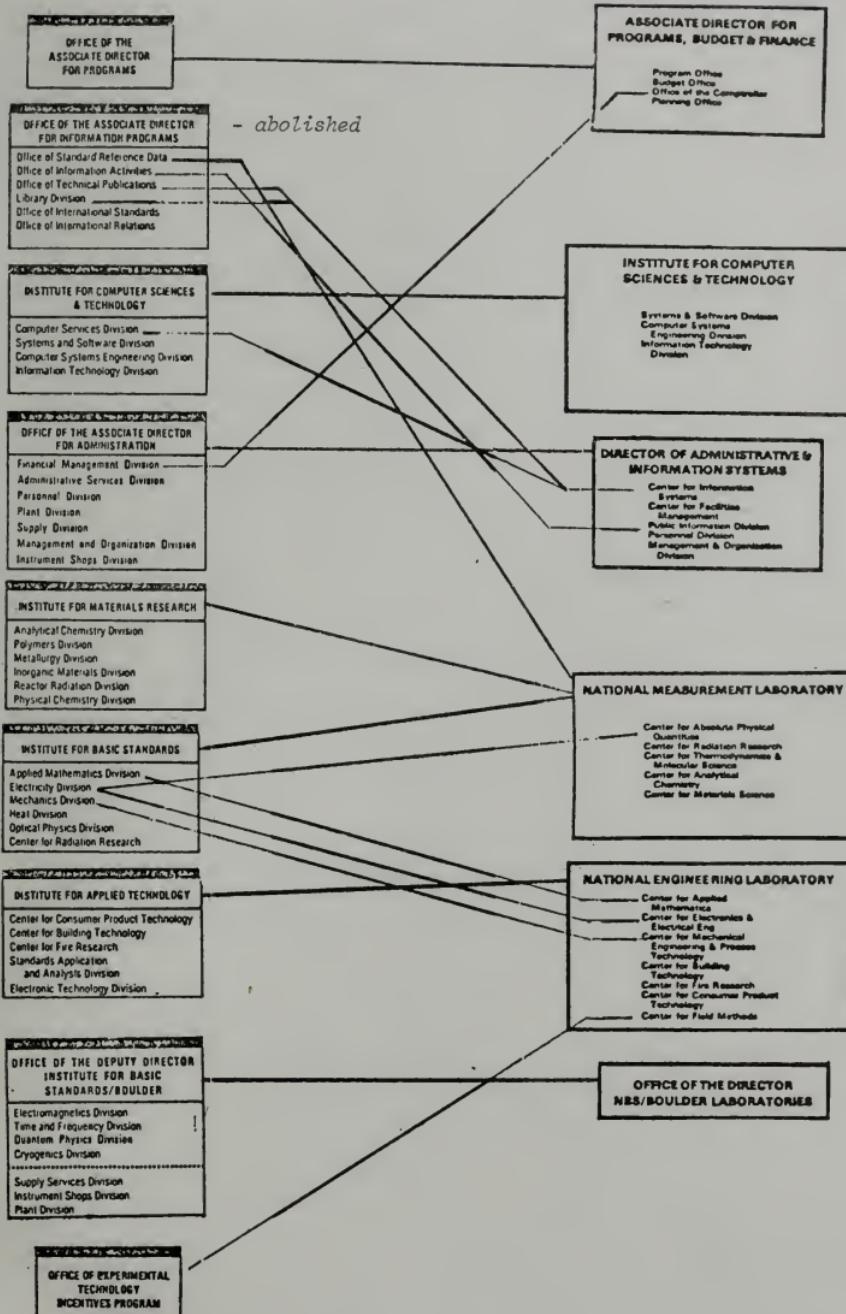
EFFECTIVE APRIL 9, 1978

U.S. DEPARTMENT OF COMMERCE

National Bureau of Standards



APPENDIX I



ORGANIZATIONAL CROSSWALK

UNIVERSITY OF FLORIDA



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